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STERLING C. ROBERTSON DAM AND LIMESTONE LAKE ON THE NAVASOTA RI--ETC(U)
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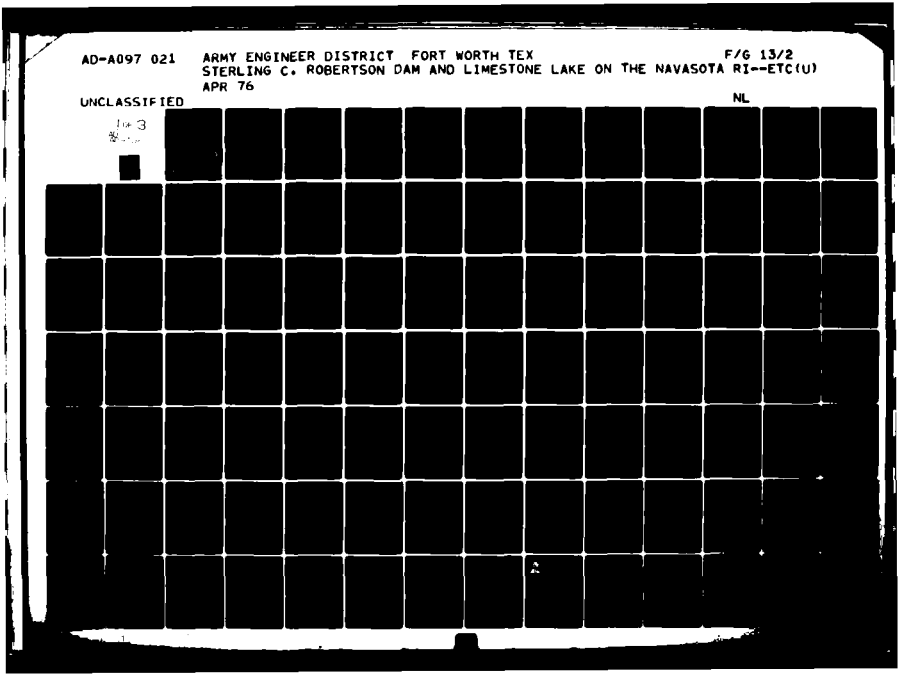

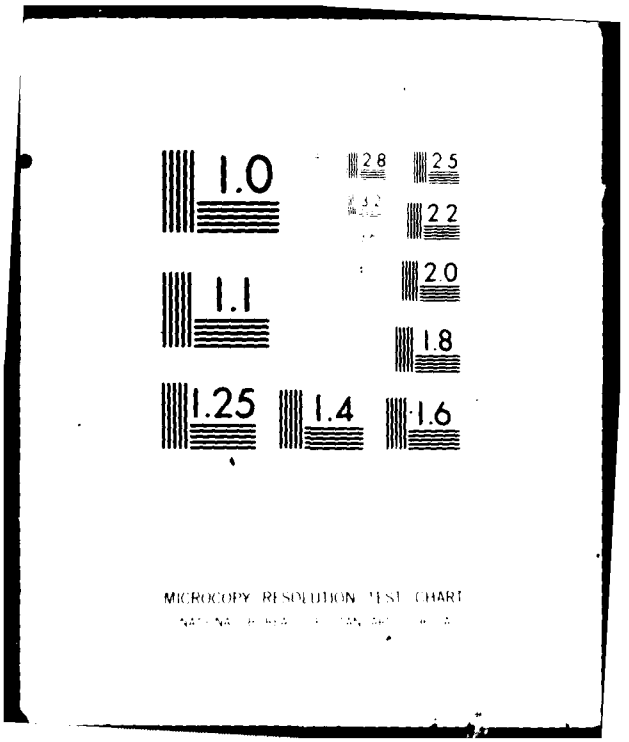
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DRAFT ENVIRONMENTAL STATEMENT

STERLING C. ROBERTSON DAM
and
LIMESTONE LAKE
on the
NAVASOTA RIVER, TEXAS
(Leon, Limestone and Robertson Counties)

Prepared by

U. S. ARMY ENGINEER DISTRICT, FORT WORTH, TEXAS

Apr[illegible]1976

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

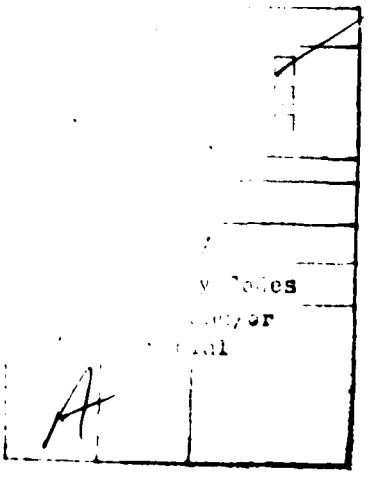
Brazos River Authority
Draft Environmental Statement
Leon County
Limestone County
Limestone Lake
Navasota River, Texas
Robertson County
Sterling C. Robertson Dam

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Draft environmental statement for Sterling C. Robertson Dam and Limestone Lake, Navasota River, Texas (Leon, Limestone and Robertson Counties); this project will supply water for municipal, industrial, and agricultural use by those who contract with the Brazos River Authority in central and north-central Texas. Additional aquatic habitat is expected to be beneficial to a wide variety of aquatic species. Some terrestrial habitat will be converted to aquatic habitat. Secondary development adjacent to this area will deplete terrestrial habitat. Loss of

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. taxable land will temporarily affect the local area, but land values will increase after the project is completed. The lake would have no flood-control storage so flood control waters would be passed on downstream.



SUMMARY

Sterling C. Robertson Dam and Limestone Lake on the Navasota River, Texas (Leon, Limestone and Robertson Counties)

(X) Draft Environmental Statement ( ) Final Environmental Statement

Responsible Office: U.S. ARMY ENGINEER DISTRICT, FORT WORTH, TEXAS
Colonel Joe H. Sheard, District Engineer
P.O. Box 17300
Fort Worth, Texas 76102
Telephone: 817 334-2301

1. **Name of Action:** (X) Administrative ( ) Legislative

2. **Description of Action:** The Brazos River Authority, a duly constituted state agency, has made application for a permit under Section 404 of Public Law 92-500, 86 Stat. 816, for the construction of the Sterling C. Robertson Dam on the Navasota River in Robertson and Leon Counties at river mile 124.5. This site is about 22 miles northeast of Franklin, Texas, and about six miles northwest of Marquez, Texas. The purpose of the project is to supply water for municipal, industrial, and irrigation use by entities or persons who have contracted, or will contract, with the Brazos River Authority. Water from the lake would first be used to meet the immediate local industrial demand for 25,000 acre-feet annually with possible future increases.

3. (A) **Environmental Impacts:** Dependable water supply for present and projected future local and downstream demands for municipal, industrial and agricultural water supplies. Direct and indirect economic benefits expected to accrue for a sizable portion of central and north-central Texas. Additional aquatic habitat expected to be beneficial to a wide variety of aquatic species and water quality is expected to remain good.

(B) **Adverse Environmental Effects:** The project will require the conversion of some 14,200 acres of terrestrial habitat to aquatic habitat. Secondary development adjacent to the area will further deplete terrestrial habitat. Minor and temporary adverse impacts will occur during construction affecting both terrestrial and aquatic species. Loss of taxable land will temporarily adversely affect the local area; however, the enhanced land values after completion of the project should soon make up for these losses.

4. **Alternatives:** Development of facilities other than the proposed project to supply local and downstream water supply demands. Various sizes of development at the site of the proposed dam and lake. No development of any facilities.

5. **Comments Requested:**

U.S. Department of the Interior
Bureau of Land Management
Fish and Wildlife Service
National Park Service
Southwestern Power Administration
Bureau of Reclamation, Region 5
Bureau of Outdoor Recreation, South Central Region
Office of Environmental Project Review

Federal Energy Administration
U.S. Department of Transportation
Environmental Protection Agency
Advisory Council on Historic Preservation
U.S. Department of Agriculture
    Coordinator Environmental Quality Activities
    Area Director Oklahoma-Texas Area
    Forest Service
    Soil Conservation Service
Agricultural Stabilization and Conservation Service
U.S. Department of Commerce
    Deputy Assistant Secretary for Environmental Affairs
    National Marine Fisheries Service, NOAA
    NOAA National Weather Service
Federal Power Commission
Department of Health, Education, and Welfare
    Office of the Assistant Secretary for Administration and Management
    Environmental Impact Coordinator
Department of Housing and Urban Development

The State of Texas
    Office of the Governor
Brazos Valley Development Council
Heart of Texas Council of Governments
Brazos River Authority

Southern Methodist University
    Department of Anthropology
Texas Committee on Natural Resources
Texas Archaeological Society
Texas Archeological Survey
Citizens Environmental Coalition
Sierra Club
The Nature Conservancy
National Wildlife Federation
Environmental Defense Fund
National Audubon Society
Environmental Coalition of North Central Texas
EAC of North Central Texas
Sportsmen Clubs of Texas
Izaac Walton League of America
League of Women Voters of Texas
Wildlife Management Institute

6. Draft Statement to CEQ_____

ENVIRONMENTAL STATEMENT
STERLING C. ROBERTSON DAM AND LIMESTONE LAKE ON THE NAVASOTA RIVER, TEXAS
(Leon, Limestone and Robertson Counties)

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SECTION I — PROJECT DESCRIPTION

1.01 **Authority.** The basis for the U.S. Army Corps of Engineers responsibility to regulate the disposal of dredged or fill material is the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500). Section 404 of that Act charges the Secretary of the Army, acting through the Chief of Engineers, to regulate the discharge of dredged or fill material in the waters of the United States. This authority under Section 404 was implemented by the Corps of Engineers by CFR 209.120 on 25 July 1975. The implementation is phased over three years. The Navasota River, as a principal tributary to a navigable stream (waters of the United States) comes under regulatory authority of the Corps of Engineers on 1 July 1976. This regulatory authority is primarily to insure that the chemical/biological integrity of waters of the United States is protected from the irresponsible and unregulated discharges of dredged or fill material that could permanently destroy or alter the character of these valuable resources. This program provides for the consideration of all concerns of the public - - environmental, social, and econcomic - - in the Corps' decision making process to either issue or deny permits. As a part of its responsibility to protect water quality, the Corps of Engineers' Section 404 permit program has thus been extended to many areas that have never been regulated before.

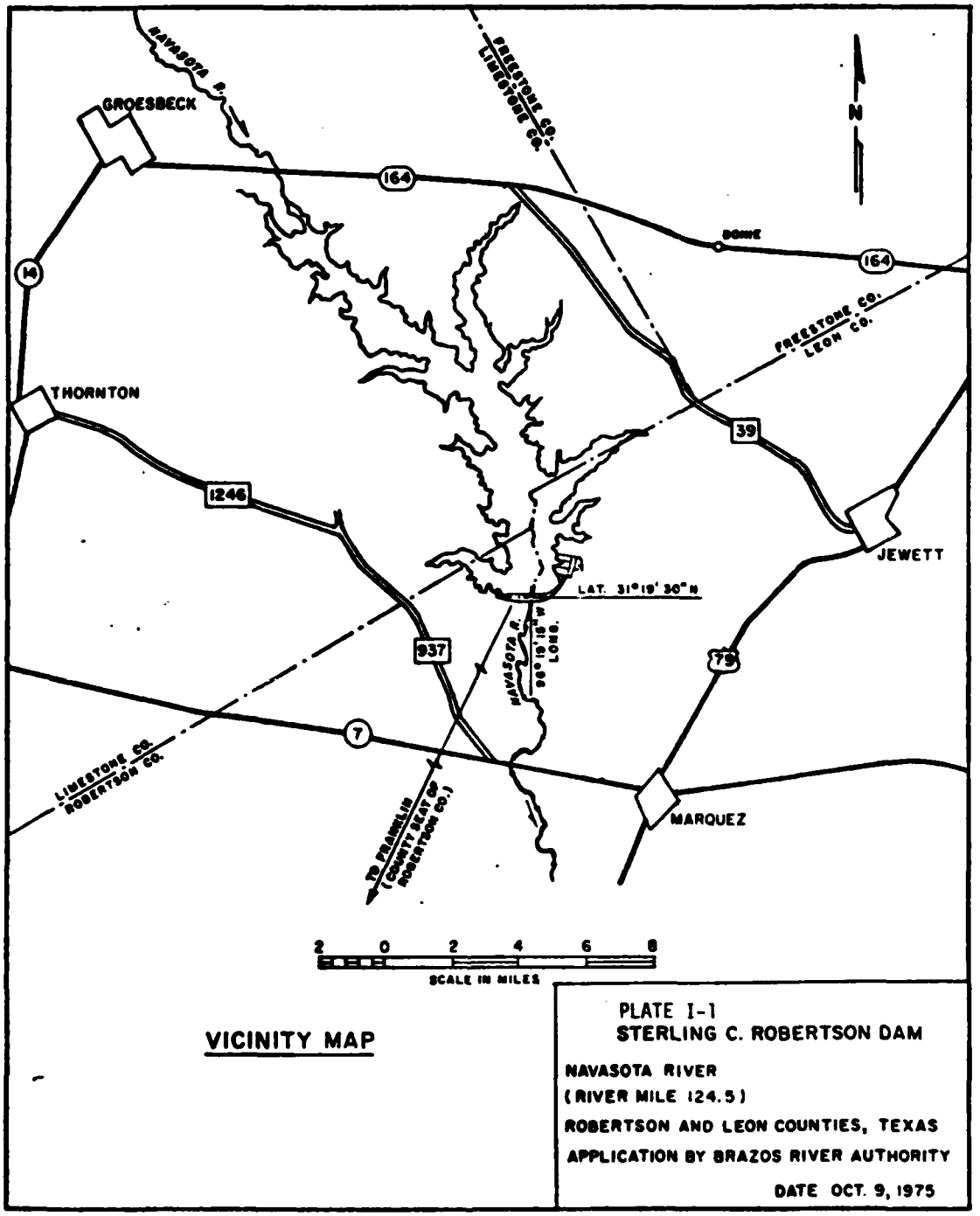
1.02 **Nature of the Proposed Action.** The Brazos River Authority, a duly constituted state agency, has made application for a permit under Section 404 of Public Law 92-500 for the construction of the Sterling C. Robertson Dam on the Navasota River in Robertson and Leon Counties at river mile 124.5 (see plate 1-1). This site is about 22 miles northeast of Franklin, Texas, and about 6 miles northwest of Marquez, Texas. The purpose of the project is to supply water for municipal, industrial and irrigation use by entities or persons who have contracted, or will contract, with the Brazos River Authority. Water from the lake would first be used to meet local water needs in the Navasota watershed (Brazos River Authority (BRA), 1974a). Local industrial requirements are estimated to be about 25,000 acre-feet per annum initially, with possible future increases (Texas Water Rights Commission, 1974).

1.03 Limestone Lake would have a surface area of 14,200 acres and would impound 217,494 acre-feet of water at elevation 363 feet mean sea level (msl), its normal operating level. The lake would cover 12 to 15 miles of the existing Navasota River and would have shore-line of about 130 miles. The lake would have no flood-control storage so flood waters would be passed on downstream.

1.04 The lake would be included in the system of operation of certain reservoirs in the Brazos River Basin authorized by the Texas Water Rights Commission Order of July 23 1964, amended July 23, 1968. The system operation, as described in the Water Rights Commission Permit No. 2950 issued to the Brazos River Authority on July 29, 1974, is detailed in appendix A-7. Water Rights Commission Permit No. 2950 stipulates that the Brazos River Authority determine low flows prior to beginning impoundment, correlate low flow at a station upstream from the reservoir site with low flow at the damsite, and pass through the dam all low flows up to 6 cubic feet per second. Low flows greater than 6 cubic feet per second would be passed through to serve superior downstream water rights. When low flow falls below 2 cubic feet per second, a minimum of 2 cubic feet per second will be passed through the dam until low flows cease.

Net evaporation loss values for the 30 year period (1941 - 1970) as taken from Texas Water Development Board Report 64 are: 1) average annual net reservoir loss, 2.31 ft.; 2) maximum calendar year evaporation, in 1951, 5.17 ft.; 3) minimum calendar year evaporation, in 1957, 0.21 ft.

1.05 **Land Acquisition.** Land acquisition criteria and guidelines for the Sterling C. Robertson Dam and Lake Limestone project have been established by the Brazos River Authority (see



VICINITY MAP

PLATE I-1
STERLING C. ROBERTSON DAM
NAVASOTA RIVER
(RIVER MILE 124.5)
ROBERTSON AND LEON COUNTIES, TEXAS
APPLICATION BY BRAZOS RIVER AUTHORITY
DATE OCT. 9, 1975

appendix A-4). Land needed for construction of the dam and appurtenant structures (about 800 acres) will be acquired in fee, except for oil and gas rights. The necessity of excluding public access to the dam and areas immediately downstream for safety reasons will be taken into consideration in acquiring the land. Land in the area to be inundated by the lake will be acquired in fee up to elevation 363 feet mean sea level (normal pool level), with the landowner retaining mineral rights (but with recovery operations limited as needed to accommodate the lake and its operation. Additional details of the land acquisition activities, project structures, and project operation are given in appendixes A-1 through A-7.

1.06 Certain clearing and grubbing activities will be required in connection with the construction of the Sterling C. Robertson Dam and Lake Limestone both within and above the 363 foot msl contour. Details of these activities are given in appendix A-3.

1.07 **Project Costs.** The total cost of the project has been estimated by the Brazos River Authority to be $50,000,000.

1.08 No state or Federal tax monies or funding will be involved in meeting the costs of the project. The project will be financed by the Brazos River Authority through the sale of bonds to private investors. Revenue from the sale of water to the Texas Utilities Generating Company and other future contractors for water will be used to pay off the bonds and operate and maintain Limestone Lake.

1.09 Construction of the project was initiated July 22, 1975, and a contract for construction of the embankment and spillway portions of the project was awarded in July, 1975, to the Texas Bitulithic Company in the amount of $15,678,567.00. The project is expected to be completed in 1978, and become fully operational by 1980.

SECTION II — ENVIRONMENTAL SETTING WITHOUT THE PROJECT

2.01 **Physiography.** The reservoir will be situated near the southwestern end of the Sandy Hills region which comprises the northern part of the East Texas Timber belt. The boundary between the Black Prairie and the East Texas Timber Belt is approximately five miles north of the upstream end of the proposed reservoir. The Sandy Hills region is characteristically hilly to gently rolling with the topography controlled by alternating sands and shales. The non-marine shales and sands exposed in the reservoir area exhibit little resistance to erosion. Drainage lines are frequent and the valleys are generally broad and shallow with low rounded interstream divides.

2.02 The area has supported a relatively dense forest cover composed of Oak, Hickory, and Elm in contrast to the Black Prairie to the northwest dominated vegetationally by grasses and the Piney Woods to the southeast dominated by Pines, Oaks, Sweetgum and Hickory on the uplands and Oak, Sugarberry, Elm, and Bush Palmetto in the bottomlands. Forests in the general area of the reservoir are presently confined mainly to the Navasota River floodplain and its tributaries.

2.03 **Geology.** The proposed damsite and reservoir area will be situated entirely on the outcrop belt of the Wilcox group (see plate II-1). The Wilcox group overlies the Midway group which outcrops to the west, and is overlain by the Carrizo formation which outcrops to the east. The outcrop belt of the Wilcox group is 16 to 20 miles wide in the project area and the strike of Wilcox formations is approximately North 35° East. The Wilcox consists mainly of unconsolidated sediments deposited in a terrestrial environment. For a more detailed description of the Wilcox group, see appendix F-I.

2.04 **Ground Water.** The Carrizo-Wilcox aquifer is the major source of ground water in Leon and Robertson Counties and to a lesser extent in Limestone County. Ground water withdrawals in 1960 were about 550 acre-feet but represent a very small percentage of the quantity that could be developed.

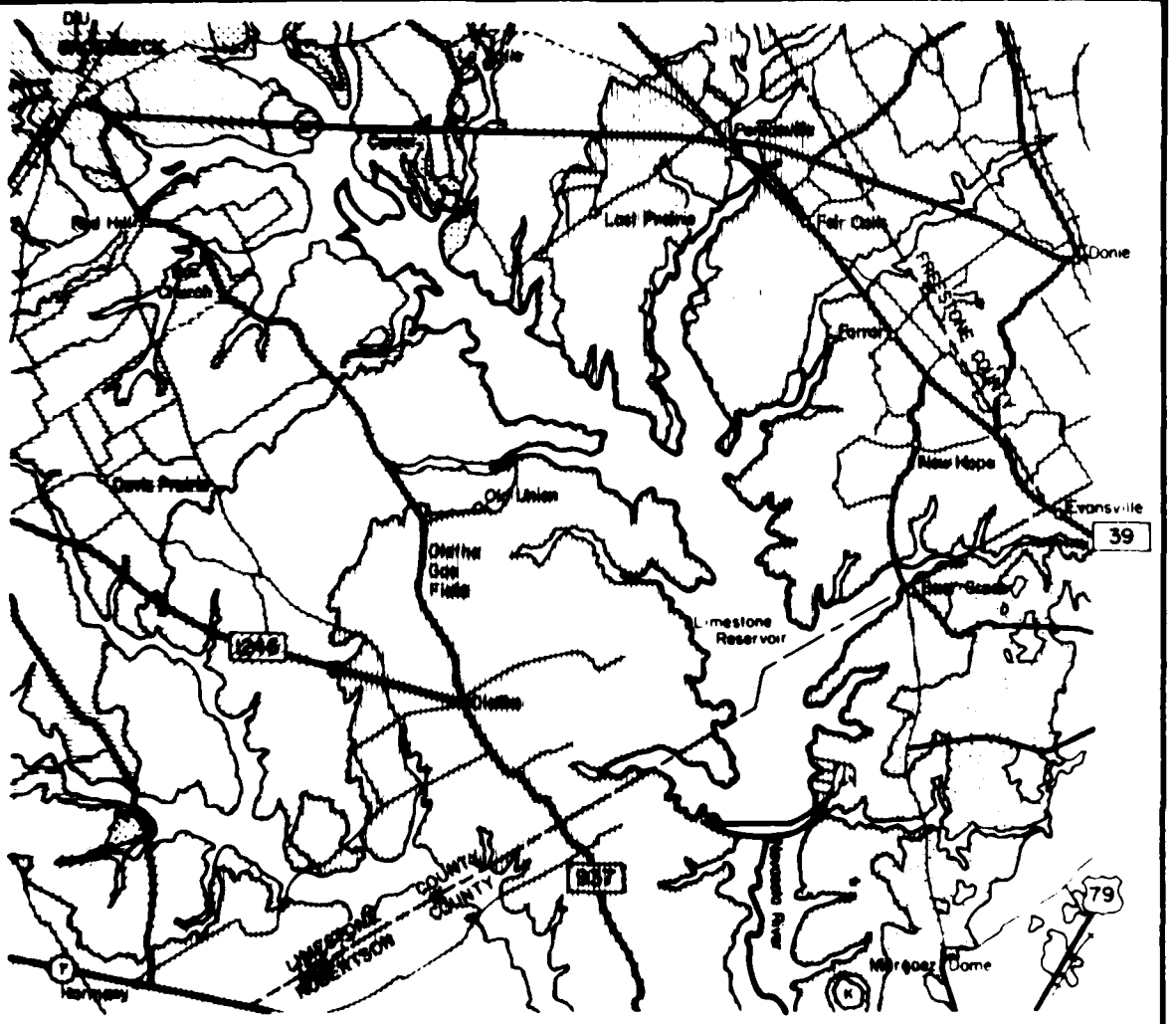
2.05 Alluvium in the Navasota River Valley provides limited amounts of water for domestic and stock purposes through hand dug wells. These wells are typically about 36 inches in diameter and usually less than 40 feet in depth. Yields are strongly dependent on seasonal rainfall conditions.

2.06 **Economic Geology.** Mineral production in the 3-county area as reported by the U. S. Bureau of Mines for 1970, 1971, and 1972 consisted of sand and gravel, natural gas, petroleum, clays, natural gas liquids and stone. The average value of production for the 3-year period was: Limestone County $4,911,000; Leon County $3,150,000; and Robertson County $51,000.

2.07 **Potential Lignite Resources.** Kaiser (1974) estimates that there are 10.4 billion short tons of lignite in Texas within 200 feet of the surface and that about 80 percent of these reserves occur in the Calvert Bluff formation. This formation crosses the project site, but preliminary investigations indicate no continuous deposits of commercially recoverable lignite in the reservoir area (BRA, 1976).

2.08 Although largely undeveloped, lignite has been mined at various places in the vicinity of the proposed reservoir. From 1907 to 1930, 1½ to 2 million short tons were taken from 6 to 9 foot seams near Bear Grass and Evansville in northwestern Leon County. Seven mines, ranging from 30 to 110 feet in depth, were located about 8 to 10 miles northeast of the proposed damsite.

CORPS OF ENGINEERS U.S. ARMY



LEGEND

- ALLUVIUM
- FLUVIATILE TERRACE DEPOSITS
- CARRIZO FORMATION
- CALVERT BLUFF FORMATION
- SIMSBORO FORMATION
- HOOPER FORMATION
- MIDWAY GROUP
- K UPPER CRETACEOUS UNDIVIDED

ROBERTSON DAM AND LIMESTONE RESERVOIR

GEOLOGY

U S ARMY ENGINEER DISTRICT, FT WORTH

PLATE II-1

Similar operations near Donie, in Freestone County, were reported by Lonsdale and Crawford (1928). Potential commercial deposits also occur in Limestone County. Kaiser (1974) estimates that there are 169 million short tons within 200 feet of the surface in Limestone County.

2.09 Lignite seams in this region were formed in a delta environment and are considered to be better in quality than those Calvert Bluff lignites formed in a fluvial environment (northeast of the Trinity River) and those formed in a lagoonal environment (south of Bastrop County). Deltaic lignite, in contrast to fluvial and lagoonal types, has generally a low ash content, moderate sulfur content, high heating value, a tabular shape and a wide extent (up to 10 miles). Analyses indicate that lignites from Bear Grass and Evansville are fairly typical of the deltaic lignite zone between the Colorado and Trinity Rivers.

2.10 **Soils.** Soil types and their areal extent are relatively well known in the project area consistent with the coverage given the area in geologic and soils survey work. These data have been presented on generalized county soil maps prepared by the Soil Conservation Service of the U.S. Department of Agriculture (USDA) in 1960, 1961, and 1962. Related published soil surveys have furnished information on the agriculture and climate of the area. In 1971, 1972 and 1973, surveys and studies were made which provided bases for making estimates of yields of the common agricultural crops under defined levels of management and various land-use capability interpretations.

2.11 In general, there are three upland soils series groups and two floodplain soils series groups represented. The upland types are: 1) Axtell-Tabor Series Group (which covers approximately two-thirds of the area), 2) Kenney-Freestone Series Group, and 3) Crockett-Mabank Series Group. The floodplain types are: 1) Gowen-Hahatche Series Group, and 2) Kaufman-Gladewater Series Group.

2.12 **Climate.** Historical meteorological data are not available for the Sterling C. Robertson Dam and Lake Limestone project area. The nearest weather station is located in Mexia, Texas, *about 25 miles northeast* of the Sterling C. Robertson Damsite. The climatological summary presented herein was extracted from U.S. Department of Commerce (undated).

2.13 Mexia is located in the northeastern portion of Limestone County, in North Central Texas, near the border of the Blackland Prairie and the Post Oak Belt. The surrounding terrain is level to rolling and is drained by the Navasota River. The city lies in the humid, subtropical belt that extends northward from the Gulf of Mexico, and its climate is dominated by this during spring, summer, and autumn. In the winter, the interaction of cold polar air from the north with the moist tropical air from the Gulf is frequent over the region. Rainfall at Mexia, averaging 37.44 inches annually, is fairly evenly distributed throughout the year, except for a relatively dry period in July and August. The driest year on record at Mexia was 1954 when 20.44 inches of rain fell. The wettest year was 1957 with 58.03 inches of rain. Short periods of heavy rainfall may occur at almost anytime of the year. Most rainfall is associated with thunderstorms.

2.14 The summer months are hot and humid. During the winter and early spring months, cold polar air masses push down through the region producing sudden temperature changes. When these cold air masses are overrun by moist air from the south, several days of cold, cloudy weather follow. These conditions are usually of short duration. Winters are normally mild and periods of cold weather usually last for only a few days at a time. An average of 36 days per year experience a temperature drop to 32° F. or below. Snowfall is rare and not a significant source of moisture.

2.15 Mean annual relative humidity is 80 to 85 percent at 6:00 a.m., 55 to 60 percent at noon, and 50 to 55 percent at 6:00 p.m. Central Standard Time.

2.16 Mexia has an average growing season (freeze-free period) of 255 days. The average date of the first freeze in the fall is November 26th. The average date of the last spring freeze is March 15th. Mexia receives an average of about 60 to 65 percent of the total possible sunshine annually. January is the cloudiest month. The prevailing wind is from the south.

2.17 Table II-1 shows the means and extremes of temperature and precipitation recorded in Mexia during the period 1931 to 1965.

2.18 **Surface Water Quality.** Historical data on surface water quality in the Navasota River are available from several sources. The U.S. Geological Survey has water quality stations on the Navasota River near Bryan, near Easterly, and near Groesbeck. Both the Bryan and the Easterly stations are downstream from the proposed project site. The Groesbeck station is about 1 - 2 miles upstream from the headwaters of the proposed lake. Some physiochemical data are available on the quality of the water at these stations from 1967 to the present. Clark (1973) included a number of water quality parameters in his ecological investigation of the Navasota River. SwRI (1975) conducted a year-long water quality investigation in the upper portion of the Navasota River and its tributaries.

2.19 One of the sampling stations of Clark (1973) was at the crossing of Texas State Highway 7 and the Navasota River - - a location approximately 3 miles south of the proposed Sterling C. Robertson damsite. Clark compared the chemical characteristics of the Navasota River with concurrent measurements made in the Trinity River, the Brazos River, and the Colorado River, and to the average values for North American rivers. Silica values for the Trinity River and the Brazos River were below the average value. Sodium, chloride, sulfate and potassium values for Brazos River waters were more than three times the North American average. The Brazos also shows consistently higher values for dissolved solids, hardness and conductivity. This general condition is due largely to the geology of the upper watershed where extensive saline strata are naturally exposed. The general chemical characteristics of the waters of the Navasota River as measured by Clark appeared to be of better general quality than those of the Brazos River.

2.20 The water quality investigation of SwRI (1975) used sampling stations which would exemplify those locations likely to be impacted by the proposed activities. They measured 43 parameters, 37 in the laboratory and 6 in the field, and compared the results with existing or proposed standards set forth by the U.S. EPA (1973), the U.S. Public Health Service Drinking Water Standards of 1968, and the Texas Water Quality Board (1973). The standards reviewed included five categories: drinking, irrigation, livestock, aquatic life and recreational uses. They found that 23 of the total of 43 parameters examined never exceeded the most stringent standard and another 9 exceeded the standard in less than 10 percent of the analyses. Each of the latter cases was found to be from samples taken during or immediately following a heavy rainfall. The 11 parameters which exceeded a standard more than 10 percent of the time were alkalinity, boron, chloride, iron, mercury, oil and grease, phenols, suspended solids, total dissolved solids, turbidity and vanadium.

2.21 Table B-1 contains a summary of the U.S.G.S. water quality data for the Groesbeck station. A summary of the analyses of the 43 parameters measured by SwRI (1975) and a more detailed discussion of the 11 parameters which were found by SwRI to exceed standards more than 10 percent of the time, can be found in appendix B-1.

2.22 **Point Source Discharges.** The Brazos River Authority's *Water Quality Management Plan for the Brazos Basin* (BRA, 1975) lists point sources in the Navasota River Basin. Five sources which lie within the drainage area of the Limestone Lake are given in table II-2, which also shows recommended discharge permit limitations. None of these dischargers are located within 5 miles of the Limestone Lake site, so secondary sewage treatment is expected to be adequate treatment for these dischargers (BRA, 1975).

Table II-I

Means and Extremes of Temperature and Precipitation Recorded In Mexia, 1931-1965

Month	Temperature (°F)							**	Precipitation Totals (Inches)								Mean number of days					Month
	Means			Extremes								Snow, Sleet						Temperatures				
																		Max.		Min.		
	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Mean degree days	Mean	Greatest daily	Year	Mean	Maximum monthly	Year	Greatest daily	Year	Precip. .10 inch or more	90° and above	32° and below	32° and below	0° and below	
(a)	35	35	35	35		35		11	35	35		35	35				12	12	12	12	12	
Jan	57.0	35.7	46.4	86	1943	-1	1949	629	3.12	3.91	1932	0.8	6.0	1944			4	0	2	14	0	Jan
Feb	60.8	39.2	50.0	87	1940	0	1951	441	3.10	3.31	1932	0.3	3.6	1940			6	0	*	7	0	Feb
Mar	68.0	44.7	56.4	95	1946	12	1943	308	2.94	5.95	1965	0.2	2.0	1954			4	0	0	4	0	Mar
Apr	76.3	54.7	65.5	96	1963	30	1950+	80	3.84	4.12	1944	T	T	1938			6	*	0	0	0	Apr
May	82.8	63.1	73.0	97	1963+	41	1954	8	4.82	4.70	1959	0	0				6	3	0	0	0	May
Jun	90.2	69.8	80.0	105	1936+	55	1964	*	3.33	4.15	1938	0	0				5	16	0	0	0	Jun
Jul	94.8	72.9	83.9	110	1954	62	1950+	0	2.05	4.10	1936	0	0				3	27	0	0	0	Jul
Aug	96.7	72.5	84.6	110	1936	60	1944+	0	1.78	3.62	1958	0	0				3	28	0	0	0	Aug
Sep	90.6	67.2	78.9	109	1939	40	1942	1	3.35	11.80	1932	0	0				4	20	0	0	0	Sep
Oct	81.6	56.8	69.2	102	1938	32	1957+	53	2.83	4.40	1957	0	0				4	4	0	*	0	Oct
Nov	68.1	45.0	56.6	90	1948	20	1950	255	3.15	3.73	1944	0.2	5.5	1937			4	0	0	2	0	Nov
Dec	59.8	38.2	49.0	84	1955+	9	1950	514	3.13	2.95	1935	0.2	4.5	1963			5	0	*	9	0	Dec
Year	77.2	55.0	66.1	110	Jul. 1954+	-1	Jan. 1949	2289	37.44	11.80	Sep. 1932	1.7	6.0	Jan. 1944			54	98	2	36	0	Year

(a) Average length of record, years.

T Trace, an amount too small to measure.

** Base 65°F

+ Also on earlier dates, months, or years.

* Less than one half.

2.23 **Non-point Sources.** No quantitative data are available on the non-point source discharges from rural or urban areas into the Navasota River. Measurements taken within the River and in tributary streams by SwRI (1975) included some water from rural and urban runoff.

Table II-2

Point Sources in the Limestone Lake Watershed

		Proposed NPDES Permit			
Name	**Q MGD**	**BOD mg/1**	**SS mg/1**	**Cl_2 mg/1**	**Fecal Col. #/100ml**
City of Mexia	1.0	20	20	1.0	200
TDMH & MR Mexia State	0.45	20	20	1.0	200
City of Jewett	0.1	20	20	1.0	200
City of Teague	0.21	30	30	1.0	200
City of Groesbeck	0.28	30	30	1.0	200

MGD = millions of gallons per day
mg 1 = milligrams per liter
Q= total volume discharged
BOD= Biochemical oxygen demand
SS= suspended solids
Cl_2= chlorine residual in effluent

2.24 **Ground Water Quality.** SwRI (1975) found that existing data on the quality of well water was available for some wells in Limestone and Robertson Counties, but none of the wells located near enough to the proposed activities of project construction to be meaningful. Using the same procedures as they had with the surface water quality analyses, 6 wells were sampled for 12 months. The comparison of the results with the most stringent drinking water standards, existing or proposed, showed only 7 parameters that ever exceeded the standards, and 5 were in excess in more than 10 percent of the samples taken. Those five were: boron, iron, phenols, total dissolved solids and turbidity.

2.25 Appendix B-6 contains a more detailed discussion of the five parameters named above as well as a summary of the ground water analyses performed.

2.26 **Air Quality.** The only air quality data available from the area of the Sterling C. Robertson Damsite and Limestone Lakesite are those collected by SwRI (1975). They measured existing levels of particulates, sulfur dioxide, oxides of nitrogen, carbon monoxide, and ozone. Between December 1973 and December 1974, 16 air quality samples were taken for periods of up to 24 hours. They found the area to be nearly pollutant-free and about what could be expected in any agricultural ranching community with a sandy soil type and little or no industry and commerce.

2.27 More details on the air quality measurements can be found in appendix H-1, which includes a summary table of air quality measurements and applicable standards.

2.28 **Noise.** The only data available on existing noise levels in the Lake Limestone area are those collected by SwRI (1975). Twelve test sites were chosen in the areas of the Lake Limestone site and the sites of the Oak Knoll and Twin Oak electric generating plants. Ambient noise was recorded at each site at four different times during the day: 1) early morning; 2) mid-morning; 3) afternoon; and 4) evening.

2.29 Two types of noise data were measured at each site: 1) a histogram of dBA level versus number of readings; and 2) an octave band analysis. The former show the percentage of readings at each level over a 20-dBA range for a five minute time interval while the latter indicates the frequency bands which contribute the most to overall noise measurement at each test site. Simultaneous measurements of relative humidity, barometric pressure, wind velocity and direction, and temperature were made.

2.30 A summary of the results is given in appendix G-1. The low levels of noise found are what one might expect to find in rural areas with low densities of commerce and industry.

2.31 **Recreation.** Recreational opportunities and facilities in the area of the proposed Lake Limestone are limited. The main attractions in the area are Lake Mexia and Fort Parker State Park. Lake Mexia is a 1200 surface acre lake offering boating, swimming, water skiing and fishing. Fort Parker State Park contains 1,485 acres of wooded parkland with 750 acre Lake Springfield being the main attraction. Another attraction in the area is the Old Fort Parker State Historic Site. The fort was restored in 1967 and features authentic log blockhouses and stockade along with pioneer memorabilia.

2.32 The Lake Limestone area is popular for deer hunting. Other game found in the area are quail, dove, and squirrel. Although hunting is popular, it is limited by an absence of public land. Hunters either own the land, lease it from the owners for hunting, or receive permission to hunt from the landowner.

2.33 There are a few major recreational attractions outside the three-county area of Leon, Limestone and Robertson Counties. Within a sixty mile radius of the damsite, Lakes Waco and Navarro Mills provide camping facilities as well as facilities for picknicking, boating, water skiing, swimming and fishing.

2.34 **Flora** The proposed lake is to be located in the Post Oak Savannah vegetational area (Gould, 1969). This region includes both oak-hickory or deciduous forest formation and true prairie association of the grassland formation. The topography is gently rolling to hilly with elevations between 300 and 800 feet msl. Annual precipitation is about 40 inches. Upland soils are light colored acid sandy loams or sands. Bottomland soils are darker acid sandy loams or clays (Gould, 1969).

2.35 According to SwRI (1975), a total of 210 species were identified resulting from 2 series of plant collections from the Navasota River Study area. In the study, two general vegetative sites were determined, i.e., the forest and prairie types. Of the 14,200 acres to be inundated by the proposed lake, about 9,500 acres (66.7 percent) are in forest, and about 4,700 acres (or 33.3 percent) are in prairie. Species common to the upland forest site included post oak *(Quercus stellata),* several grasses *(Panicum* sp.), winged elm *(Ulmus alata),* slender copperleaf *(Acalypha gracilens),* holly *(Ilex* sp.), blackjack oak *(Quercus marilandica),* bull briar *(Smilax bona-nox),* flatsedge *(Cyperus* sp.), and Spanish mulberry *(Callicarpa americana).* Common bottomland forest species included pecan *(Carya illinoensis),* post oak *(Quercus stellata),* hackberry *(Celtis* sp.), elm *(Ulmus* sp.), and holly. Species common in the prairie site included *Croton* sp., prairie crusae *(Crusea tricocca),* Bermuda grass *(Cynodon dactylon),* flatsedge, *Panicum* sp., sneezeweed *(Helenum amarum),* Drummond nailwort *(Paraonychia drummondii), Paspulum* sp., coast sandbur *(Cenchrus incertus),* sedge *(Carex* sp.), *Oxalis* sp., and vetch *(Vicia* sp.).

2.36 There are no known species in the project area classified as rare, endangered or threatened by extinction.

2.37 More comprehensive lists of the plant species of the Navasota River project area and the area investigated by SwRI (1975) are included in tables C-1 and C-2.

2.38 **Fauna.**

2.39 **Fish.** A total of 56 species belonging to 14 families and 9 orders were taken during 136 collections at 105 localities on the Navasota River between May 1967 and July 1968 by Rozenburg, et al. (1972). Several types of habitats were sampled, including sandy stretches, gravel and sand riffles, narrow gravel-bottomed streams, and large mud-bottom reservoirs. Some of the more common species collected are found throughout most or all of Texas. However, certain species reach the limits of their recorded range in the Navasota drainage area. The stoneroller *(Campostoma anomalum),* apparently reaches its southeastern boundary in this watershed. The blackspot shiner *(Notropis atrocaudalis)* and blackspotted topminnow *(Fundulus olivaceous)* apparently reach their western boundary, and the western limit of the ranges of the dollar sunfish *(Lepomis marginatus),* bantam sunfish *(L. symmetricus),* and goldstripe *(Etheostoma parvipinne)* are at the eastern edge of the Navasota drainage area. The fauna collected is different from other parts of the Brazos River Drainage in that the species are more representative of eastern drainages, i.e. Austroriparian (Blair, 1950), rather than the rest of the Brazos (Rozenburg et al., 1972).

2.40 There are no known species considered rare, endangered, or threatened by extinction in the project area. A more comprehensive list of the fish species of the Navasota River, Texas, is included in table C-3.

2.41 **Birds.** The diversity of birds in Texas naturally reflects the extremely varied climate, physiography, and vegetation of the State. Each region supports certain species adapted to a particular combination of weather, terrain, and flora (Oberholser et al., 1974).

2.42 From over 540 species reported in the state by Peterson (1963), field personnel sighted and identified 103 different species in the project area and an additional 10 more not specifically identified (SwRI, 1975). Some of the more common species were: starling, turkey vulture, meadowlark, crow, cardinal, mourning dove, Brewer's blackbird, barn swallow, robin, Savannah sparrow, dickcissel, song sparrow, tufted titmouse, Carolina chickadee, Harris' sparrow, common grackle, Canada goose, junco, snow goose, killdeer, scissor-tailed flycatcher, upland plover, mallard duck, vesper sparrow, lesser yellowlegs, and white-rumpted sandpiper. Also, one reported endangered species, the American peregrine falcon, was sighted in the study area (SwRI, 1975).

2.43 According to TOES (1975), species listed as rare, endangered, or threatened by extinction and having a range that is either statewide or includes all or part of the study area are:

Species	Range in State	Habitat Preference
Swallow-tailed kite *(Elanoides forficatus)*	eastern half	open woodlands
bald eagle *(Haliaeetus leucocephalus)*	statewide	lakes & larger rivers
golden eagle *(Aquila chrysaetos)*	statewide	mountains & hill country

osprey *(Pandion haliaetus*	statewide	lakes & reservoirs
peregrine falcon *(Falco peregrinus)*	statewide	lakes & mountains
prairie falcon *(F. mexicanus)*	statewide except extreme east	open country and arid areas
Merlin *(F. columbarius)*	statewide	open country

2.44 A detailed list of the birds sighted in the study area is included in table C-4.

2.45 **Mammals.** The study area is located along the north to south border that divides Blair's (1950) Texan and Austroriparian biotic provinces (see fig. II-1). There is an important intermixing of faunas in this transitional area. This is demonstrated by the fact that of the 49 mammals reported to occur in the Texan, 41 also occur in the Austroriparian. Within the Texan there is also an interdigitation (i.e., different ecological associations existing in the same area because of local soils related differences) of forest and grassland associations. The Austroriparian or eastern species found in the Texan are restricted mostly to the oak-hickory forest or flood plain forest. Similarly, the species entering the Texan from the west are largely limited to the prairies (Blair, 1950).

2.46 As a result of sightings during field trips to the area, 20 species of mammals were reported in the study area (SwRI, 1975). The most frequently sighted mammals were the raccoon and the armadillo. Coyote, deer, bobcat, and oppossum were also common. Because of unfavorable weather conditions very few identifications were obtained from trapping rodents, resulting in little information on these species (SwRI, 1975).

2.47 Davis (1974) reports an additional 23 species of mammals with a range in the state that includes all or a portion of the study area. These species include mainly bats, rodents, and carnivores.

2.48 There are no known species in the project area classified as rare, endangered, or threatened by extinction.

2.49 A list of the mammals reported in the study area is included in table C-5.

2.50 **Amphibians and Reptiles.** Raun and Gehlbach (1972) reported, either from the literature or by observation, 71 amphibian and reptile species in Limestone, Leon, and Robertson counties. These included 4 sirens, salamanders and newts, 18 frogs and toads, 11 turtles, 10 skinks and lizards, 1 alligator, and 27 snakes.

2.51 In field studies, SwRI (1975) sighted and identified 19 of the same species (12 frogs and toads, 4 skinks and lizards, and 3 snakes) and one additional species of lizard. The amphibians were sighted mainly during the warmer months at stream and tank sites. Very few reptiles were observed because they followed the same seasonal cyclic pattern caused by the lower temperatures in January and February.

2.52 The alligator, *Alligator mississippiensis*, is the only known species classified as rare or endangered known to exist in the project area.

Figure II-1. The location and extent of the Navasota River Basin within the Biotic Provinces of Texas (Blair, 1950).

2.53 A list of the amphibian and reptile species known or reported from the project area is included in table C-6.

2.54 **Navasota River Limnology.** An inventory of the aquatic and benthic organisms of the Navasota River conducted by Clark (1973) included taxonomic investigations of the blue-green algae, bacteria, protista (green algae, diatoms, and protozoans), invertebrates (flatworms, nematodes, rotifers, roundworms, arthropods, clams and mussels, and snails) and vertebrates (bony fishes). Check lists of the reported species are included in table C-7 (aquatic organisms) and table C-8 (benthic organisms).

2.55 **Archeological Elements.** The Upper Navasota Dam and Reservoir (Lake Limestone) will affect portions of Leon, Limestone, and Robertson counties in east central Texas. The project area is located in the western edge of the east Texas timber belt: soils are claypan Alfisols of the Lufkin-Axtell-Taber associations (Godfrey et al., 1973). Soils within the present flood plain are of the Navasota series.

2.56 Through interagency agreements with the Brazos River Authority, the Texas Archeological Survey Project of the University of Texas has made a survey of the area affected by the project. The affected area was surveyed to a projected level of 370 feet to insure full coverage of the reservoir margins. Additional data as reported by local collectors in adjacent areas were recorded as a part of the survey to provide comparisons to data and artifacts collected within the confines of the project itself.

2.57 With a few exceptions, the sites in the survey area are contained within a thin sandy matrix up to one foot thick overlying clays of Eocene Age. The exceptions include those sites which are contained in sands significantly deeper than one foot. Many of the sites are now in cultivated or pasture lands which were formerly wooded. These have been cleared of timber within recent years with the aid of bulldozers; this, in itself, constitutes an inherent threat to the integrity of archeological deposits by churning the surface layers. This effect is compounded in this area especially by virtue of the shallow, fragile nature of the artifact-bearing deposits. Burrowing animals have also contributed to the mixing of layers. The occasional pot-hunter, superficially, appears to have caused little damage.

2.58 As a consequence of these combined activities, it can be postulated that the vertical separation of artifacts accumulated through time at any given shallow site within the reservoir area has been obscured to the point that visible separation s not possible. However, that does not mean the sites are no longer of potential value. Gross trends of vertical distribution and horizontal clusterings of various artifacts can yield information of significance in determining resource use or activity-specific areas such as chipping localities and cooking areas. Time-diagnostic artifacts may be compared with adjacent areas to reveal the general age ranges.

2.59 **Archeological Evidence** As a result of the survey by Prewitt (1974), 52 archeological sites were recorded within or around the margins of the proposed reservoir. Four sites had been previously recorded near the upper end of the reservoir, and an additional eight sites are known in the area. Of more than 60 archeological sites in the affected area, 16 were deemed by the Texas Archeological Survey to be worthy of further investigation (Prewitt, 1974): (41 LN 20, 21, 25; 41 LT 12, 14, 17, 26, 30, 31, 32, 33, 34, 35, 42, 44; 41 RT 2.)

2.60 Under a permit from the Texas Antiquities Commission, the Brazos River Authority contracted to have archeological salvage operations carried out by the Texas Archeological Survey at the Barkley site (41 LN 20) and the Louie Sadler site (41 RT 2). The report covering this salvage activity indicates that both sites appear to be just above the normal flood levels, on

erosional remnants along either side of the Navasota River but, according to local informants, they are subject to partial inundation by the occasional short-term flood. Both yielded evidence of extensive prehistoric utilization.

2.61 Although much important information was obtained from these excavations (Prewitt, 1975), the data from these two sites alone are too meager to allow complete or accurate definition of the adaptive strategies of the Paleo-Indian inhabitants. Accordingly, the Brazos River Authority is presently making arrangements to have competent salvage operations carried out at the other 14 sites recommended for further investigation above (BRA, 1976).

2.62 The sites are fairly evenly distributed along the mainstem valley of the river with the large majority being located on the crests or slopes of the eroded margins of the valley.

2.63 Additional archeological details are given in appendix D.

2.64 **Land Use.** Current land use in Leon, Limestone and Robertson Counties is predominately agricultural. Ranching exceeds all other agricultural pursuits with livestock accounting for most of the effort within the three-county area.

2.65 In addition to ranching some truck crops, cotton, sorghum, grains, melons, peas, peaches and pecans are harvested in the three-county area.

2.66 Although some firewood is cut and sold, the harvesting of trees for income is limited. Mining activities in the area are presently limited to the production of clay, sand, and gravel. Some oil and gas is produced in the three-county area.

2.67 **Socioeconomic Characteristics.** The socioeconomic parameters of Leon, Limestone, and Robertson Counties are heavily influenced by the basically rural makeup of this three-county area. Leon County is classified as 100 percent rural as it does not contain a community of 2,500 or more inhabitants. Limestone and Robertson are classified as 67.3 and 64 percent rural respectively, whereas the State of Texas has about a 20 percent rural population. Detailed information pertaining to the socioeconomic attributes of the three-county area are contained in appendix F.

2.68 A decline in population has been experienced since 1930 in the three-county area, and this trend is projected to continue throughout the remainder of this century. A portion of this decrease in population is attributed to those of wage-earning age seeking employment elsewhere, usually in the metropolitan areas. This exodus has influenced the birth rates and the death rates of the individual counties leaving them significantly lower and higher than the respective rates for the state. As expected, the median age of the population for county is also considerably above that of the state. The state is consistently higher than the three counties in percentage of population below age 45 and is lower in percentage of all age brackets above age 45.

2.69 Educational achievement for those persons 25 years old and older in 1970 ranged in median years of schooling from 9.3 years in Robertson County to 9.8 years in Limestone County to 10.1 years in Leon County. The median years of education for the state, for persons 25 years old and older, was 11.6 years. For many, lack of education reduces their ability to compete for more desirable jobs and results in their entrenchment in the lower paying occupations.

2.70 The total population of the 3-county area in 1970 was 41,244 with a racial composition of 70.1 percent whites and 29.9 percent blacks. The state's racial composition in 1970 was 12.9 per-

cent blacks and 87.1 percent whites. The Spanish American ethnic group, counted primarily in the white race, but includes some blacks and other races, accounted for 3.8 percent of the population in the 3-county area, whereas this group accounted for 18.4 percent of the 1970 state population.

2.71 **Housing.** The three counties and the state have reasonably the same percentage of owner-occupied homes. However, the percentage of renter-occupied units is considerably higher in the state than in Leon, Limestone, and Robertson Counties. Leon County, with 28.1 percent of its houses for sale or rent, almost doubles that percentage in the other two counties and triples that of the state (SwRI, 1975). High vacancy among rental units is not unexpected considering the loss of population experienced by the counties.

2.72 **Government.** According to SwRI (1975): "The three-county area has basically a typically rural form of government. At the county level, each of the counties is administered by a County Judge and a Commissioner's Court, and a general law-type of government is used by most of the municipalities in the area; these make no local ordinances and depend upon state laws for their community. A few of the municipalities have a homerule form of government and provide local ordinances which supplement state laws."

2.73 **Employment.** Employment in the category "agriculture, forestry, and fisheries industy" (U.S. Bureau of the Census, 1972) is significantly higher in the three counties of Leon, Limestone and Robertson than it is for the state (table E-7 appendix E). However, manufacturing employment is proportionately lower than that for the state. The three-county area ranks high compared to the state in personal services.

2.74. **Occupations.** The state of Texas has a higher percentage of people in professional, technical and kindred workers, sales, and clerical occupations than the counties of Leon, Limestone and Robertson. However, the three-county area is higher than the state in farmers and farm managers, and farm laborers and farm foremen. The percentage of private household workers in the three counties is about two and one-half times that for the state.

2.75. **Unemployment.** The unemployment rate for Leon and Robertson Counties has increased at a much faster rate than the state. In April of 1975, the state had an unemployment rate of 5.9 percent, Limestone County 4.6 percent, Leon County 7.8 percent, and Robertson County 8.2 percent. (Texas Employment Commission, 1975).

2.76 **Business Patterns.** The majority of the businesses in Leon, Limestone and Robertson Counties are small, with about 80 percent of the reporting units employing seven or fewer persons. Four of the six units employing 100 to 249 persons are engaged in manufacturing, one unit in this category is engaged in mining, and the remaining one in services. Limited business opportunities exist in the three county area.

2.77. **Income Distribution.** The three-county area has more people in the lower income bracket than the state average. The area has a high percentage of families with income less than the government-defined poverty level, with Leon and Robertson counties having more than twice the average state poverty percentage. Per capita income for Leon, Limestone, and Robertson Counties were 71 percent, 74 percent, and 61 percent of the states' per capita income in 1970. The three counties have a larger percentage of families with an income level up to $6,000 than the established state average, but fewer than the state in levels above $9,000.

2.78. **Hunting and Fishing.** Access to lands for public fishing and hunting is virtually nonexistent in the three-county area. Available fishing waters include Lake Springfield and Lake

Mexia and highway crossings over the Brazos and Navasota Rivers. Hunting is generally available only to those owning land with suitable wildlife habitat and those individuals who lease hunting lands from them.

2.79. **Transportation Systems.** A well-defined transportation network exists in the three-county area. There are a total of 234 miles of railroad; over 3,100 miles of highways, streets and roads; 408 miles of power transmission lines; and 866 miles of pipeline. Leon County is the only county with a section of interstate highway. There are several private airfields in the area, but most are unimproved fields with limited facilities.

2.80. **History.** Robertson County was organized in 1838 and at that time included the present Leon, Freestone, Limestone, and Navarro Counties. In 1846, the present limits of the above counties were created.

2.81 The three-county area of Leon, Limestone and Robertson Counties was occupied by Towakoni, Kichai, Waco, Caddo, Anadarko, Delaware, and Cherokee Indians before the arrival of white settlers (Texas State Historical Association, 1952).

2.82 Early Spanish explorers crossed the area as early as 1690, and the Spanish founded missions in the area as late as 1716 (Texas State Historical Association, 1952). Indians occupied the area as late as the middle 1830's and numerous skirmishes resulted between the Indians and the white settlers.

2.83 The plantation owners from the south found the river lands suitable for cotton and brought their slaves to assist in this frontier land. The area, which has remained largely agricultural, was discovered in the early 1900's to have oil and gas deposits and boom towns sprang up. The production of oil and gas has declined, however.

2.84 Appendix D contains a more detailed historical sketch of the area, including a listing of historical sites within the three-county area.

2.85 **Future Environmental Setting Without the Project.** The future environmental setting without the project will be determined to a great extent by the activities of man in and adjacent to the upper Navasota River Basin. Changes will occur, and evaluation of probable changes, however difficult, must be carried out.

2.86 **Population Changes.** The populations of Leon, Limestone and Robertson Counties are predicted to decline throughout the remainder of this century. This decrease in population will tend to raise the median age of the citizenry, lower the birth rate, and raise the death rate in the three-county area.

2.87 **Economic Activities.** The loss of population and lack of sufficient new industrial growth in the 3-county area will cause a gradual decrease in the employment rolls through the year 2000. While it is anticipaed that the per capita income will increase at a rate faster than that of the state, it will remain significantly behind the state in actual per capita income. The trend in agricultural practices from croplands to grazing lands will continue.

2.88 **Water Quality.** The Brazos River Authority, the State of Texas, and the nation as a whole are committed to reaching the goals set forth in Public Law 92-500. The water in the upper Navasota River should remain of good quality in the future, regardless of watershed activities, since any activities will be carefully regulated regarding their effects on water quality.

2.89 **Future Water Supply Requirements.** Without the project, there would exist an im-

mediate need for industrial water supply in the local area for makeup water at the Twin Oaks and Oak Knoll electric generating stations. Since no other in-basin source is available, water would have to be brought into the area from outside the basin at significant increases in costs. Additional local and downstream water requirements anticipated would also suffer from the lack of availability of sufficient water.

2.90 **Floodplain Vegetation Trends.** The trend of clearing floodplain areas for grazing would be likely to continue in the future, since the area is not suited to the forestry industry or to more intensive agriculture. Some additional clearing could occur for the purpose of accessing mineral deposits.

2.91 **Recreation.** The reservoir site is primarily a wooded bottomland interspersed with cleared pasture areas, much of which is subject to frequent flooding. Some of the "improved" pasture areas will continue to gradually revert to native vegetation. Recreational use of the river will continue to be limited by the lack of public access and the periodic alternating periods of flooding and of low-or-no-flow conditions. Primary recreational use of the reservoir site will remain deer hunting on privately owned lands.

2.92 If no public recreation lands are set aside at the reservoir site, it is safe to anticipate changes in the open spaces and woodlands that now exist by the year 2020. Encroachment on bottomlands can be anticipated with a substantial loss in wooded cover as the land is converted for grazing. Currently the land is overgrazed. If overgrazing continues, more growth of undesirable plant species can be anticipated.

2.93 Public recreational opportunities in the three-county area will remain much as they are: Fort Parker and Old Fort Parker State Parks. Private outdoor recreation activities will continue to be comprised primarily of hunting and fishing on private lands. There will continue to be a lack of water-oriented opportunities to meet the public demand in the three-county area.

2.94 **Lignite Deposits.** It is not considered likely that the criteria used to determine the minability of lignite will be significantly altered in the future. Therefore, those lignite deposits which now exist in the area to be inundated by Lake Limestone will not be likely to be developed regardless of future activities within the area.

SECTION III — RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS

3.01 **State of Texas Land Use Authority.** At the state level, the Texas Water Quality Board, the General Land Office and the School Land Board have statutory authority to consider land use in formulating policy or in controlling activities within their respective jurisdiction. (BRA, 1975).

3.02 Although various state and local entities are authorized to exercise some sort of land use controls, no system of formal review of land use decisions which affect the major portions of Texas lands presently exists. Therefore, only informal and indirect influences rather than the classical zoning type decisions are commonly used.

3.03 The Texas Water Quality Board has influenced density of development (although not the specific use of the land) by promulgation of orders regulating septic tank installation. The Brazos River Authority presently administers such orders around Lakes Granbury and Somerville pursuant to Section 21.083 of the Texas Water Code. Similar orders can be issued and administered by a county under Section 21.084 of the Texas Water Code. In general, such orders are applicable where extensive use of septic tanks pose a threat to water quality, as might be the case adjacent to reservoirs.

3.04 Non-statutory methods of influencing land use decisions include selecting sites for such public facilities as parks, highways, reservoirs, etc.

3.05 In the preparation of the *Water Quality Management Plan for the Brazos Basin*, the Brazos River Authority reviewed all available land use plans and inventories and delineated those activities which might affect stream segment classification and waste load allocation. As future plans and land use studies are made available, they will be reviewed by the Brazos River Authority so as to determine their expected impact on water quality (*BRA, 1975*).

3.06 No conflicts are known to exist between the proposed Sterling C. Robertson Dam and Lake Limestone project and any land use plan. Should any conflicts arise during the course of the coordination and review of this environmental statement, they will be addressed in the final environmental statement.

SECTION IV — THE PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT

4.01 **Existing Water Quality.** The relatively good quality of the water in the Navasota River now and in the recent past in the area of the Sterling C. Robertson damsite and Lake Limestone has been documented by the USGS (1968-1973), Clark (1973), BRA (1975), and SwRI (1975). There is also evidence hat the poorest water quality in the Navasota River is found during or immediately following heavy rainfall and runoff (Clark, 1973; Gallaher, 1974; and SwRI, 1975).

4.02 **Adverse Effects.** Some adverse impacts on the existing water quality can be expected during the construction period primarily in the form of increased turbidity and sedimentation, increased levels of dissolved solids, and the potential for accidental spills of fuels, oils, etc., associated with construction activities. These adverse effects are expected to be held to a minimum by the regulation of activities by the Texas Water Quality Board (see discussion on water quality, appendix B-1).

4.03 While the lake is filling, and for some time following, low oxygen levels and high organic concentrations can be expected in the reservoir itself as inundated vegetation is undergoing decomposition. The generally good quality of water entering the lake can be expected to minimize this adverse condition which will be gradually lessening with time. Temperature stratification can be expected to establish a thermocline below which water temperatures will be colder, dissolved oxygen concentrations will be lower.

4.04 **Beneficial Effects.** The water quality downstream from Lake Limestone can be expected to show an improvement beginning with the impoundment of water. Decreases can be expected in coliform bacteria, turbidity, suspended solids and organic matter, color, silica, and biochemical oxygen demand (McKee and Wolfe, 1963). It is also recognized that removal of particulate matter will result in the removal of organic pollutants such as pesticides and heavy metals (LeGrand, 1966). It can be anticipated that the lake will tend to "smooth out" the extremes found in the concentrations of parameters in the river during preimpoundment studies (McKee and Wolfe, 1963).

4.05 Another downstream water quality benefit that can be anticipated following completion of the project is the low-flow augmentation which is a requirement of the Texas Water Rights Commission Permit for the Sterling C. Robertson Dam and Lake Limestone project. Under present conditions, there are often periods when there is no flow in the Navasota River throughout a large part of its reach. Details of the low-flow release requirements can be found in the description of the project operation in appendix A-7.

4.06 **Impact on Air Quality.** During construction there will be an increase in particulate matter. Watering trucks will be used extensively in an effort to keep dust to a minimum during this period. Pollutants resulting from the internal combustion engines should be dispersed by the almost ever-present winds with no adverse environmental impacts. Disposal of waste materials and materials from clearing and grubbing operations must be done in an acceptable manner with regard to air quality considerations (see appendix A-3, Vegetative Clearing).

4.07 **Noise Impacts.** Estimates of noise impacts in the area of Lake Limestone during construction and during the operational period by SwRI (1975) account for both the activities connected with the Sterling C. Robertson Dam and Lake Limestone project and the planned facilities of the Texas Utilities Service, Inc. They estimate that during the construction period, average noise levels will range from about 78 to 85 dBA, depending on the particular phase of construction. They further estimate that, assuming the construction noise levels are measured

at 300 feet from the sources, the noise levels will attenuate to background noise levels at distances of 2 to 3 miles from the construction sites. During the operational period for Lake Limestone, noise is expected to result primarily from activities related to recreation and will be made up primarily of power boat noises. Since population levels are extremely low in the area, no adverse community reaction to increased noise levels is anticipated.

4.08 **Impact on Biological Elements.**

4.09 **Fish.** Construction of the proposed dam and lake will cause some change in the local fish fauna. Riffle-dwelling species and other lotic (flowing water) fishes will be adversely affected as the reservoir fills, and streams are replaced by the lake. Suitable habitats, e.g. gravel-riffles and sandbar areas, will be inundated or destroyed by construction. The Dusky darter (*Percina sciera*) will face probable extermination in the lake area resulting from elimination of these riffle areas. In addition, other small fishes such as the ribbon shiner (*Notropis fumeus*), silverband shiner (*N. shumardi*), ghost shiner (*N. buchanani*), silvery minnow (*Hybognathus nuchalis*), tadpole madtom (*Noturus gyrinus*), bluntnose darter (*Etheostoma chlorosomum*), and slough darter (*E. gracile*) which are found almost exclusively in lotic habitats, will be adversely affected. Species already inhabiting lentic (pooled water) habitats such as gizzard shad (*Dorosoma cepedianum*), white crappie (*Pomoxis annularis*), smallmouth buffalofish (*Ictiobus bubalus*), several species of sunfish (*Lepomis sp.*), largemouth bass (*Micropterus salmoides*), and freshwater drum (*Aplodonotus grunniens*) will benefit from the reservoir. The resulting reservoir will probably develop large populations of catfish (*Ictalurus sp.*) and sunfish which are popular game species, as well as several non-game species of gar (*Lepisosteus* sp.), carp (*Cyprinus* sp.), and buffalofish (Rozenburg et al., 1972).

4.10 **Natural River.** There will be an elimination and loss of about 15 miles of riverine habitat on the Navasota River resulting from inundation. This distance represents about 8.7 percent of its total length or about 10 percent of the total distance of natural flowing river. Very little fishing presently is done in this reach.

4.11 **Habitat.** There will be a permanent loss of 14,200 acres of terrestrial wildlife habitat within the water supply pool, for which there is no mitigation land associated with the proposed project. An additional 1,000 acres will be lost as a result of dam and spillway construction and public use and access requirements. The proposed lake will increase available aquatic habitat for migrant waterfowl, shorebirds, and other aquatic species. Peripheral project lands containing upland forest and prairie habitats will be accessible to the public which could result in adverse impacts through misuse or abuse.

4.12 **Amphibians and Reptiles.** Those species now inhabiting the bottom-lands would suffer the greatest impact due to displacement by inundation. Public development at the lake and private developments in proximity to the project will cause additional displacement of upland species through reduction of available habitat and physical disturbance. Some protection and restabilization and upland populations will occur in suitable habitats along the periphery of the lake because of developmental restrictions on project lands. In the downstream area, water releases will aid in stabilizing certain bottomland species.

4.13 **Birds.** Approximately one-fourth of the avian species in the project area will be reduced or eliminated due to alteration of specific nesting, feeding, or other behavioral requirements usually associated with bottomland hardwood forests. Avian use will decline after about five years which is generally associated with decreasing lake fertility, loss of suitable nesting spots (due to death, fall, and decay of inundated timber), and reduced availability of desirable food plants. Those species that inhabit generally open country, prairies, fields, brushy plains, roadsides, etc., should suffer very little, if any, detrimental effects. Aquatically oriented species

which usually occupy lakes, ponds, mudflats, and shorelines will benefit from the proposed lake.

4.14 **Mammals.** The most seriously affected species will include those associated with the bottomland forest adjacent to the river, such as rabbits and squirrels. The whitetail deer would also be adversely impacted due to the reduction in suitable or preferred habitat. Most terrestrial species will be forced to shift their ranges in accordance with changing water levels. Aquatic species should be benefited and could, as a consequence, experience habitat expansions.

4.15 **Vegetation.** There will be a loss of species within the reservoir area, i.e., aquatic species within the 15 mile reach of the Navasota River, and terrestrial species within the 14,200 acres of the water supply pool. Aquatic vegetation affects environmental factors such as dissolved oxygen, carbon dioxide, ammonia, pH, light penetration, and siltation. Alterations of these factors could cause serious effects such as heavy algae production or eutrophication. Future public and private development around the project and in the downstream area is expected to further reduce existing species. An increase in aquatic plants can be expected along the periphery of the lake. Many of these aquatic species aid in reducing shoreline erosion, are extremely significant to wildlife, and serve as important habitat in the fishery aspect of the lake. In the downstream area, periodic water releases would aid in preserving the existing bottomland species.

4.16 **Impact on Archeological Elements.** Funding will be provided for the salvage of the 14 significant archeological sites not yet excavated (BRA, 1976). The remaining sites appear so shallow or disturbed that little additional archeological information could be obtained from them. The remainder of the sites within and around the margins of the reservoir will suffer varying degrees of direct and indirect effects. Observation of sites of similar nature (e.g. shallow sand caps overlying clay) in other reservoir areas has demonstrated the potential dangers which inundation and fluctuation of shorelines pose to archeological materials. Witty (1973) observed severe directional scour and deflation of totally inundated sites, and Prewitt and Lawson (1972) observed severe lateral erosion and deflation at sites subjected to shoreline situations.

4.17 There is no doubt that the sites in Lake Limestone will be similarly affected. The inherent nature of the principal use of the lake will contribute to directional scour of sites on the flood plain and fluctuating shoreline erosion of sites along the valley margins. Indirect (or deferred) effects will probably result from the anticipated secondary use of the reservoir as a recreation area. Wave action generated from fishing and pleasure boats should aggravate shoreline erosion, and relic hunters will undoubtedly be attracted to those sites exposed along the shoreline. These people destroy archeological sites through indiscriminate digging for the sake of aesthetially pleasing artifacts which they trade, sell, or proudly display on their mantle pieces. The results of such "pothunting" contributes little toward the understanding of prehistoric peoples other than the fact that many of them were true artisans in the manufacture of certain artifacts.

4.18 **Impact on Population.** The Robertson Dam and Lake Limestone will increase the population of the three-county area. In addition to the 200 employees in construction crews for 2½ years, a permanent work force of 10 employees will be required to operate and maintain the Brazos River Authority facility. This facility will aid the operation of the 2 electric power plants which will permanently employ an estimated 600 employees. The resulting increase in population caused by these combined facilities will help offset the declining population trends of the three counties. This past and projected loss in population is considered to have an adverse impact on the area and any slowing of this trend must be considered advantageous.

4.19 **Impact on Education.** With the exception of maintaining enrollment in the public school systems, there is no substantial impact on education anticipated. The immigration of employees and their families may stabilize the median years of education for the area.

4.20 **Impact on Racial and Ethnic Characteristics.** No significant impact on the racial or ethnic characteristics of the three-county area is anticipated.

4.21 **Impact on Employment.** Temporary employment during construction will be beneficial for local persons engaged as construction workers. An addition of ten permanent positions for the operation and maintenance of the dam and lake will help alleviate the area's downward trend in employment opportunities. The expected development around the proposed Lake Limestone will create opportunities for those engaged in construction. This development will also create employment in the service fields needed in the support of this development. Some loss in agricultural employment can be anticipated with the reduction of some 14,200 acres of rural farm and forestry lands. The creation of new job opportunities should more than offset employment losses in the three-county area.

4.22 **Impact on Occupations.** Beneficial impacts should result in occupations as more diversified employment opportunities emerge, thus, providing the local population a greater selection of potential occupations.

4.23 **Impact on County Business Patterns.** Impacts should be beneficial as new, diverse businesses evolve. Secondary developments as a result of Lake Limestone will enhance the opportunity for the creation of local businesses to provide services and goods for these developments and the affiliated recreation pursuits.

4.24 **Impact on Income Distribution.** Impacts on income distribution will be negligible but beneficial in that it should somewhat enhance the median income for the immediate area and provide a small opportunity to reduce the number of families below the poverty level.

4.25 **Impact on Hunting and Fishing.** An adverse impact on hunting will be created with the inundation of some 14,200 acreas for Lake Limestone. Private landowners and holders of hunting leases will be those mainly affected. Fishing and hunting of waterfowl will be greatly enhanced for the general public. Public access to the 14,200 acre Lake Limestone will provide lake fishing opportunities in an area lacking in this activity.

4.26 **Impact on Transportation Systems.** Improvement of existing and development of new roads and streets may be necessitated by the project. The development of roads and housing around Lake Limestone may create a significant secondary environmental impact. Careful planning prior to these developments can greatly reduce the adverse results of these actions.

4.27 **Impact on Local Government and Institutions.** The ten permanent employees required for the operation and maintenance of the project and their families will have a beneficial effect on the area suffering from emigration. There may be a temporary situation during the 2[illegible] years of construction which may cause some local concern regarding an influx of construction workers. This situation should not have an adverse effect on any local governmental agency or public institution such as schools. Long term secondary growth caused by the project may require additional actions on the part of county governments regarding land use and enforcement of local ordinances. Increased land values are anticipated to provide an additional tax base for the three-county area. Area governments may have to increase some services, such as solid waste disposal, fire protection, and law enforcement.

4.28 **Impact on Recreation.** Lake Limestone is expected to provide an esthetically pleasing lake with associated recreation for the people in Leon, Limestone, and Robertson Counties, and additional surrounding counties. It will fill a void caused by a lack of sufficient water-based recreation in the area while also providing a boost to the area's economy in the creation of lake-

related investments. The lake is expected to receive heavy visitation from fishermen during the earlier years of its existence when it offers excellent fishing during its "hot", new-lake stage. Other attributes of the lake which will contribute to high visitation are the large size of the lake (14,200 acres and 130 miles of shoreline) and the high water quality which the lake is expected to maintain. Additionally, the construction of Lake Limestone will create a river fishery below the dam. The Navasota River is not heavily fished but the construction of Sterling C. Robertson Dam and the subsequent low-flow water releases will result in a river fishery which is more productive than presently exists. The characteristics of the outflowing water will differ from the river water. Outflowing water will be less turbid and have lower levels of many nutrients. The constant flow during low-flow water releases will enhance the establishment of fishes and other organisms which cannot survive the regular summer high temperatures and intermittent stream flows of the upper Navasota River.

4.29 Present plans call for the acquisition of 5 access areas with the total acreage to be less than 150 acres. Initial development would include necessary sanitation facilities, boat ramps, and parking areas. It is expected that these areas will be further developed at some later date by the construction of picnic areas and camping facilities. This would necessitate facilities and manpower to deal with the associated problems of solid waste disposal, law enforcement, etc. The recreation development at Lake Limestone should complement existing and future area public recreation developments. Competition should exist only in camping facilities and this should be minimal.

4.30 **Impact on Texas Utilities Services, Inc.** The Texas Utilities Services, Inc., design and construction agent for Dallas Power and Light Company, Texas Electric Service Company and Texas Power and Light Company, proposes to construct two lignite-fueled steam-electric generating facilities in Limestone and Robertson Counties. Southwest Research Institute (SwRI) (1975) conducted a detailed environmental assessment of the impact of the construction and operation of these facilities on the environment.

4.31 The Texas Power and Light Company will own a facility planned to be located on Duck Creek in Robertson County. The second facility, to be owned jointly by the Dallas Power and Light Company, the Texas Electric Service Company and the Texas Power and Light Company, is planned to be located on Steele Creek in Limestone County.

4.32 The planned facilities are needed to meet the requirements for electrical energy based on long-range demand projections. The sites were selected so as to maximize economic factors while keeping adverse environmental impacts to a minimum (SwRI, 1975). Each facility will require the construction of a cooling lake.

4.33 The Twin Oak cooling lake will be constructed on Duck Creek and will have a surface area of 2330 acres at elevation 401 feet msl. It will contain 30,319 acre-feet of water, of which 13,200 acre-feet per annum will go to consumptive use of the generating station. This station will initially have a total generating capacity of 1500 MW provided by two 750 MW lignite-fuel steam generators and will include provisions to meet state and Federal standards for water discharges, emissions and air quality (MW = million watts).

4.34 The Oak Knoll facility will be located on Steele Creek in Limestone County just north of the Limestone-Robertson County Line. Oak Knoll Cooling Pond will have a surface area of 2,780 acres at elevation 382 feet msl. This pond will contain 32,818 acre-feet of water and the consumptive use of the facility is expected to be 11,900 acre-feet per annum. The plant will initially have the capacity of 1500 MW provided by two 750 MW lignite-fueled units with consideration given a possible third unit in the future to meet peaking demands.

4.35 The Sterling C. Robertson Dam and Lake Limestone Project have been planned to supply at least 25,000 acre-feet per annum required as makeup water for the cooling ponds described above and represent an essential part of the Texas Utilities Services, Inc., electric generating plant operation.

4.36 **Impact on Federal Projects.** There are two Congressionally authorized projects downstream from the proposed Lake Limestone project (i.e., Millican Reservoir at river mile 24.1 and Navasota No. 2 Reservoir at river mile 83.4). These projects would suffer reduced dependable water supply yields; however, the federal purposes of flood control, recreation, and fish and wildlife enhancement will not be affected. More detailed studies are now underway to determine the effects that the upstream projects (The Sterling C. Robertson Dam, Lake Limestone and the Twin Oak and Oak Knoll cooling ponds) would have on the dependable yield and cost allocations. Table IV-1 sums the anticipated effects on the water supply yields of the Authorized Millican and Navasota No. 2 Reservoirs.

TABLE IV-1

Effect of Proposed Upper Navasota River Basin Development on Water Supply Yields of Authorized Millican and Navasota No. 2 Reservoirs

Development Water Supply Yields (acre-feet/year)

	Present Conditions	2030 Conditions		
	Millican	Millican	Navasota No. 2	Both
Millican only	218,584	219,185	-----	-----
Millican plus proposed Upper Navasota River Projects	166,667	167,276	-----	-----
Millican and Navasota No. 2 only	-----	129,762	227,824	357,586
Millican and Navasota No. 2 plus proposed Upper Navasota River Projects	-----	131,609	153,565	285,174

SECTION V — ANY PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED.

5.01 **General.** This section contains a summary of the adverse environmental effects which are considered significantly adverse to the broad public spectrum but which are unavoidable consequences of the proposed action. It should be pointed out that any discussion of impacts is necessarily subjective, so no degree of importance of one impact over any other is intended nor should any be implied.

5.02 **Effects on Land.** A total of about 14,200 acres of mixed forest and prairie grazing land will be permanently lost to the water supply pool of Limestone Lake. Removal of this land from productive agriculture constitutes an unavoidable adverse effect.

5.03 **Effects on Water Quality.** Construction activities will result in local and temporary adverse effects on water quality, primarily in the form of turbidity and sedimentation. While the lake is filling, and for some time following, low oxygen and high organic concentrations can be expected. Following stratification, low levels of dissolved oxygen concentration will be established below the thermocline.

5.04 **Effects on Air Quality.** During construction, there will be an increase in particulate matter. Watering trucks will be used extensively to keep dust to a minimum.

5.05 **Noise.** The ambient noise level in the vicinity of the project would rise both during the construction period and during operation of the project. This would thus constitute an unavoidable adverse effect.

5.06 **Effects on Vegetation.** Approximately 9500 acres of forest and 4700 acres of prairie or grassland will be inundated and or cleared.

5.07 **Effects on Terrestrial Habitat.** The loss of 14,200 acres of mixed forest and prairie land will mean a loss of habitat to a wide variety of terrestrial and avian species. The populations of animals will either make adjustments to the displacement or be subjected to the regulation imposed by the carrying capacity of the remaining habitat.

5.08 **Effects on Aquatic Habitat.** The loss of some 12 to 15 miles of lotic (flowing water) habitat will adversely affect those species which inhabit that reach and which require flowing water (see section IV discussion on impacts on aquatic species).

5.09 **Relocations.** Although there are no inhabitants which would require relocation, it will be necessary to raise and provide bridges for three county roads and FM 1512. Three pipelines and two electric power lines will also require relocation. The highway relocations will result in temporary adverse effects on travel patterns and create temporary inconvenience to local motorists. The pipeline and power line relocations will have a temporary adverse effect on the local flora and fauna, and all the above actions will add to air, noise, and water pollution during the construction period.

5.10 **Effects on Archeological Elements.** Funds will be made available for the salvaging of materials from the most important of the known archeological sites before construction of the project is completed (BRA, 1976). While salvage work is not the best method of preservation of archeological information, it is preferable to inundation without salvage. All remaining archeological resources will suffer adverse effects, both direct and indirect, as a result of the project.

5.11 **Effects on Recreation.** Loss of the 14,200 acres of terrestrial habitat would reduce the land area available for hunting to the extent it is now permitted by private landowners. Since hunting is now the principal form of outdoor recreation in this area, this reduction would be adverse to those who hunt in the area.

SECTION VI — ALTERNATIVES TO THE PROPOSED ACTION

6.01 **General.** The Corps of Engineers is considering several alternatives in connection with the Brazos River Authority's application for a Section 404 permit for the Construction of the Sterling C. Robertson Dam and Lake Limestone: 1) denial of the permit; 2) granting the permit as requested; and 3) granting the permit with one or more conditional requirements.

6.02 **Denial of the Permit.** The denial of the permit would result in the following losses projected to 1 July 1976 (BRA, 1976):

DIRECT COSTS

Planning and engineering	1,108,000
Permits and special studies	131,000
Administration and finance	382,000
Lands	4,057,000
Construction	5,014,000
Subtotal	$ 10,692,000

ADDITIONAL COSTS

Interest paid on bonds	10,139,000
Penalties paid for materials in process	892,000
Contract abandonment costs	244,000
Site restoration costs	3,820,000
Total	$ 25,788,000

Partially offsetting the above losses would be the following credits:

Net salvageable lands	3,121,000
Interest earned on project funds	4,557,000
Total credits	$ 7,678,000

The total net cost of project abandonment as of 1 July 1976 would therefore be $16,771.500 ($24,449,500 - $7,678,000).

AREA ECONOMIC LOSSES

Limestone, Leon, and Robertson counties, in which the project is located, have all been designated by the Economic Developmnet Administration as redevelopment area counties under the Public Works and Economic Development Act of 1965, as amended. All three counties are characterized by declining populations, low employment rates, high commuting rates (work outside home county), and low per capita income and family incomes.

Information obtained from the Executive Director of the Central Texas Economic Development District on March 16, 1976, indicates that the above trends were continuing through 1976 (BRA, 1976).

The direct payrolls associated with construction of the Sterling C. Robertson Dam and Lake Limestone project are estimated to be $3,600,000 in the 18 months that will be required to complete the project after July 1, 1976. The maintenance and operation payrolls at the project will total an estimated $4 million over a 40-year period. These would, of course, be forgone if the project were abandoned.

Additional losses are pointed out in the March 26, 1976 letter from the Brazos River Authority (see Section IX).

LAND USE LOSSES

Disruption caused to the agricultural activities on the 6900 acres of land which will have been acquired by 1 July 1976 has not been estimated or included in the above cost estimates, nor have any other secondary costs. Clearing and habitat losses or disruptions have already occurred on much of the project land and could not be effectively restored to prior conditions.

6.03 **BRA Alternatives.** If it is determined that the permit application should be denied, then the following alternatives which have previously been investigated by the Brazos River Authority will become available:

1) No development of any facilities;
2) Development of facilities other than the proposed project to supply local and downstream water supply demands; and
3) Various sizes of development at the site of the proposed dam and reservoir.

6.04 No Development. Failing to develop this or any facility for either local or downstream water supply needs would result in postponing the utilization of a valuable, locally abundant mineral, lignite coal. The electric generating plants, if built, would require the importation of water at significantly higher costs. Other details of this alternative can be found in Section II, "Future Environmental Setting Without the Project."

6.05 Sources of Water Other than the Proposed Project. Alternative sources of water other than the proposed project were considered both in terms of meeting local water demands and meeting downstream water demands.

6.06 Consideration was given to the use of water in the proposed Millican Reservoir, an authorized Corps of Engineers project, as an alternative to satisfy both present and projected future local and downstream water supply needs; especially the known local industrial need for 25,000 acre-feet per year by 1979. While Millican Reservoir would yield sufficient water for part of both the present and projected future local and downstream water supply needs, the Millican Reservoir project is still in the preconstruction planning stage and it is not likely to be completed in time to meet the immediate industrial demands in the local area. Even if Millican Reservoir were to be completed in time to meet the immediate local industrial demand, the pumping distance would be 6 times the distance from Lake Limestone and would involve pumping water to an elevation 150 feet higher, resulting in high pumping costs, transportation facility costs, and a high degree of energy consumption when compared with the costs of supplying the same amount of water from Lake Limestone.

6.07 Another alternative considered in providing for local and downstream water needs was the proposed Navasota No. 2 Reservoir, an authorized project of the Corps of Engineers. However, since the planned completion date for this reservoir is 2010, insufficient planning and design has been undertaken to make it a contender for supplying water to satisfy either the present or anticipated future local and downstream water demands for several decades.

6.08 Sites other than the proposed Lake Limestone site were considered in hydrologic investigations of the upper Navasota River Watershed by the Brazos River Authority. Only two of the sites tested were found to be capable of supplying sufficient water for the immediate industrial water supply demand. The Lake Limestone site is the most efficient in terms of being able to satisfy both present and anticipated future local and downstream water supply requirements and at the same time minimizing adverse environmental impacts (BRA, 1974).

6.09 Transfer of water from the Brazos River to meet the local needs for industrial cooling water was considered. This would require releases of water from storage in reservoirs upstream, since there is no water left available from unregulated flows of the Brazos. The pumping distance from the Brazos River to the proposed power plant cooling ponds is three times further than from the proposed Lake Limestone. This would bring about higher pumping and transportation facility costs as well as higher energy consumption. This alternative fails to

provide any additional water for other needs in the local area either now or in the future and fails to provide water to meet the present and future projected needs in the downstream areas.

6.10 Alternative Sizes of the Project. Several sizes for the proposed Lake Limestone were considered as alternatives (BRA, 1974). The minimum size to satisfy the immediate local industrial demand would be a reservoir capable of yielding 25,000 acre-feet of water per year. This would not, however, provide for other immediate local and downstream water needs that may arise, nor would it provide for the increased future needs of any municipality, industry, or agricultural operation in either the local or downstream areas.

6.11 The Brazos River Authority conducted studies to determine the optimum size for the proposed Limestone Lake in terms of both the most efficient yield of water from a single reservoir at this site and in terms of the most efficient yield of water from the watershed through a reservoir system operation when Millican, Navasota No. 2, and Limestone Lake are all considered together. The size proposed is the optimum to satisfy these considerations (BRA, 1974).

6.12 **Granting the Permit as Requested.** If it is determined that the permit should be granted to the Brazos River Authority as requested, then the overall environmental impacts would be those primarily addressed by this document.

6.13 **Granting of a Conditional Permit.** A conditional permit may be granted if it is determined that it would be required to reduce or mitigate environmental losses.

6.14 Mitigation Lands. If it were determined that unavoidable losses would occur to the habitat of a species considered rare, endangered, or threatened with extinction, and if this loss were considered to be significant, the Corps of Engineers could recommend that authorization be given the Brazos River Authority by the State of Texas to acquire appropriate lands for mitigation.

6.15 Incremental Lake Filling. If it were determined that there would be a significant period of time between the initial water supply needs and future water supply needs, the Corps of Engineers could recommend a staged filling procedure. This could result in postponing the loss of the entire terrestrial habitat to the ultimate water supply pool. This requirement would, however, preclude the utilization of the multilevel withdrawal feature planned for the outlet works of the dam during the time the water surface is at the initial lower stage pool elevation. It could also be assumed that there would be periods when much of the terrestrial habitat above the lower stage pool elevation would be inundated by flood waters. Inundation of much of the vegetation would be likely to severely reduce its value as wildlife habitat. It should also be recognized that this conditional requirement would necessitate increased costs to redesign and construct the dam and appurtenances so as to enable staged filling of the lake.

SECTION VII — THE RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY.

7.01 **Trends.** Local land use has been gradually moving toward the less intensive agricultural use, grazing. Populations in the local rural areas have been declining as have the populations in the entire three-county area.

7.02 **Environmental Losses.** The proposed action will remove from agricultural productivity some 14,200 acres of land, about two-thirds of which is wooded, presently being used for grazing. There will be a loss to the tax base as 14,200 acres of land are converted from private to public ownership. This same area will be lost as terrestrial wildlife habitat, and as private recreational hunting lands for those who presently are able to hunt there. Approximately 12 to 15 miles of a free-flowing (although intermittent) river with much natural beauty for those presently able to enjoy it would be lost. Additional losses will occur locally as secondary effects of the action. The proposed action would preclude the construction of a Federal flood control reservoir at that site. However, the Corps determined in previous studies that the proposed Lake Limestone damsite was too far upstream for a flood control reservoir to be economically feasible.

7.03 **Environmental Benefits.** The proposed action will provide benefits as follows:

1) A dependable water supply yield which can be used for both local and downstream (as far as the Gulf of Mexico) demands for municipal, industrial, and agricultural water supplies (generally, downstream agriculture increases in intensiveness as one moves to the Brazos River and on toward the Gulf of Mexico).
2) The man-made lake, open to the public, will be esthetically pleasing to a large number of visitors and will provide lake habitat not now available for fish and waterfowl.
3) Secondary economic and social benefits will accrue to those people and entities within the three-county area and the state of Texas. Land values in the areas adjacent to the lake will increase, adding to the tax base to a degree expected to exceed the losses noted above.

SECTION VIII — ANY IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES WHICH WOULD BE INVOLVED IN THE PROPOSED ACTION SHOULD IT BE IMPLEMENTED.

8.01 **Land.** Approximately 14,200 acres of land, about two-thirds of which is presently wooded, plus approximately 1000 additional acres which will ultimately be used for relocations, access roads, public use areas, etc., would be irretrievably committed for the life of the project. The most significant changes would be the conversion of 14,200 acres of the present area now terrestrial to a 14,200 surface acre lake. Secondary effects adjacent to the lake will result in a variety of land use changes which will depend on the degree of state and local land use controls applied to them.

8.02 **Ecosystems.** Ecosystems presently existing on land within and adjacent to the project area will be irreversibly disrupted. The aquatic ecosystems presently existing within the 12 to 15 miles of river to be inundated will be irretrievably modified.

8.03 **Energy.** Determination of the quantity of energy required to construct the Sterling C. Robertson Dam and Lake Limestone would be virtually impossible, since it would include all human energy contributions in addition to the energy expended to manufacture all project components and the energy expended by construction activities. Energy requirements were considered carefully by the Brazos River Authority when studying alternatives to the proposed action. All energy expended in the process of completing the project would be irretrievably consumed.

8.04 **Archeological Elements.** Preliminary archeological surveys have indicated that the area encompassed by Lake Limestone contains potentially significant archeological information relative to understanding the interaction between prehistoric cultures which developed in adjacent areas. Salvage operations on the most significant sites will be completed before inundation occurs (BRA, 1976). Analysis of the remaining sites has shown that they are fragile in nature and that they will suffer irreversible adverse effects from both direct and secondary impacts of dam construction and lake impoundment. These same adverse impacts can be expected to be incurred by as yet undiscovered sites within the area of the lake.

SECTION IX — COORDINATION

9.01 **Public Notice.** The Fort Worth District, U.S. Army Corps of Engineers, on December 3, 1975, issued a public notice in connection with the Brazos River Authority's application for a permit pursuant to Section 404 of the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500). A copy of this announcement appears on the following pages.

9.02 **Future Coordination.** The summary page at the beginning of this environmental statement lists the names of the individuals and agencies to which this report is being sent for review and comment. Future coordination activities, including comments received from individuals and agencies and the responses to those comments, will be included in the final environmental statement.

DEPARTMENT OF THE ARMY
FORT WORTH DISTRICT, CORPS OF ENGINEERS
P. O. BOX 17300
FORT WORTH, TEXAS 76102

REPLY TO
ATTENTION OF:

SWFOD-R W-N-443-41-PERMIT-141

PUBLIC NOTICE 3 December 1975

Interested parties are hereby notified that application has been made to the District Engineer for a Department of the Army permit for a structure in navigable waters in this Engineer District.

NAME OF APPLICANT: Brazos River Authority
P. O. Box 7555
Waco, Texas 76710

WATERWAY AND LOCATION: Navasota River, River Mile 124.5,
Leon and Robertson Counties, Texas

CHARACTER OF WORK: Construction of the Sterling C. Robertson Dam consisting of a reinforced concrete spillway section with five 40 ft X 28 ft tainter gates. The earth filled dam will contain approximately 6,500,000 cubic yards of material with a total length of 8,000 feet. The water storage reservoir formed will be called Lake Limestone.

AUTHORIZATION FROM OTHER AGENCIES:

Texas Water Quality Board Certification dated November 13, 1975.

Texas Water Rights Commission, State Permit No. 2950, for construction and operation.

Texas Antiquities Committee, Permit No. 76 for Archeological Investigation.

The issuance of a permit for this structure is considered a major Federal action significantly affecting the quality of the human environment, therefore, an Environmental Impact Statement is being prepared by the Fort Worth District Corps of Engineers.

Additional information may be obtained from the office of the District Engineer, Fort Worth District, Corps of Engineers, 819 Taylor Street, Fort Worth, Texas, any time between 8:00AM and 4:45PM., Monday through Friday, excluding holidays.

The application will be processed pursuant to Section 404 of the Federal Water Pollution Control Act Amendments of 1972. Any

person who has an interest which may be adversely affected by the issuance of a permit may request a public hearing. The request must be submitted in writing to the District Engineer within thirty days of the date of this notice and must clearly set forth the interest which may be adversely affected and the manner in which the interest may be adversely affected by the activity.

Evaluation of the probable impacts involving deposits or discharge of dredged material into navigable waters will include the application of guidelines established by the Administrator of the Environmental Protection Agency.

This public notice is being distributed to all known interested persons in order to assist in developing facts on which decision by the Corps of Engineers can be based. For accuracy and completeness of the record, all data in support of or in opposition to the proposed work should be submitted in writing setting forth sufficient detail to furnish a clear understanding of the reasons for support or opposition. The decision whether to issue a permit will be based on an evaluation of the probable impact of the proposed activity on the public interest. That decision will reflect the national concern for both protection and utilization of important resources. The benefits which reasonably may be expected to accrue from the proposal must be balanced against its reasonably foreseeable detriments. All factors which may be relevant to the proposal will be considered; among those are conservation, economics, aesthetics, general environmental concerns, historic values, fish and wildlife values, flood damage protection, land use classification, navigation, recreation, water supply, water quality and, in general, the needs and welfare of the people. No permit will be granted unless its issuance is found to be in the public interest.

Comments on these factors will be accepted and made part of the record and will be considered in determining whether it would be in the best public interest to grant a permit. Comments must be submitted to the District Engineer, P. O. Box 17300, Fort Worth, Texas 76102, on or before 5 January 1976.

DISTRICT ENGINEER
FORT WORTH DISTRICT
CORPS OF ENGINEERS

BRAZOS RIVER AUTHORITY

4400 COBBS DRIVE P O BOX 7555 TELEPHONE AREA CODE 817 776 1441

WACO, TEXAS 76710

March 26, 1976

Colonel Joe H. Sheard
U. S. Corps of Engineers
Ft. Worth District
P.O. Box 17300
Ft. Worth, Texas 76102

Dear Colonel Sheard:

In response to a request for information from Dr. Walt Gallaher of the Environmental Resources Section, Ft. Worth District Office, we have prepared the following summary of some of the economic impacts that would result if the Brazos River Authority's application for a Section 404 permit for its Sterling C. Robertson Dam and Lake Limestone project were denied and, as a result of such denial, construction was stopped on July 1, 1976, the date on which the requirements for such a permit will become applicable to this water conservation project.

On Attachment 1 is a tabulation of the estimated direct financial loss that the Brazos River Authority would incur. In compiling this estimate of loss a deliberate effort was made to be conservative: for example, we assumed that land acquired for the project could be sold for its full acquisition cost, which would probably not be the case. Even with this conservative approach, the estimate indicates that the Brazos River Authority would suffer a direct financial loss of more than $18,000,000.

As tragically wasteful as such a loss of public funds would be, however, there would be other, even larger, adverse economic impacts which are summarized in the following paragraphs.

Limestone, Leon and Robertson Counties, in which the project is located, have all been designated by the Economic Development Administration as redevelopment area counties under the Public Works and Economic Development Act of 1965, as amended. All three counties are characterized by declining populations, low employment rates, high commuting rates (people working outside of their home county), and low per capita and family incomes. Detailed demographic and economic information illustrating these

conditions in the three counties is presented in the report entitled Assessment of Environmental, Social and Economic Impacts of Proposed Upper Navasota Reservoir submitted to the Environmental Resources Section of the Ft. Worth District Office under cover of letter dated 6 October 1975.

Information obtained from the Executive Director of the Central Texas Economic Development District on March 16, 1976, indicates that these trends were continuing through 1973. According to this information, the population of Limestone County declined 12% from 1960 to 1974. The per capita annual income in Limestone County is $3,225, ranking it 219th among Texas counties in this respect. Since 1972, known plant closings in Limestone County have resulted in the loss of 700 employment positions, of which only an estimated one-half have been regained in the economic improvement currently being experienced in the area. According to data contained in the Texas Almanac, 1972-1973, Leon and Robertson Counties are suffering even more acute economic problems than is Limestone County.

Lake Limestone will be a key factor in significantly improving the economy of the three-county area. Limestone, Leon and Robertson Counties each have vast near-surface deposits of lignite that have never been put to use. There is now a great deal of interest in using this important resource in the thermal generation of electricity to help meet the urgent energy needs of the nation. However, large quantities of water are necessary for this purpose and Lake Limestone is the only feasible source from which water in the needed amounts can be supplied in this area.

As a direct result of anticipated availability of water from Lake Limestone, Texas Utilities Generating Company has announced plans to construct two steam electric generating plants, one west of Lake Limestone in Limestone County and one to the southwest in Robertson County. The construction of these plants, and the cooling lakes and other support facilities that will be located at each, will generate construction payrolls estimated at $101,000,000 over a 10-year period. The estimated operational payrolls at the two plants would total $210,000,000 over a 40-year period. These payrolls, totaling an estimated $311,000,000 over a 40-year period, will be lost to the local economy if Lake Limestone is not completed.

The direct payrolls associated with construction of the Sterling C. Robertson Dam and Lake Limestone project are estimated to total approximately $3,600,000 in the 18 months that will be required to complete the project after July 1, 1976. The maintenance and operation payrolls at the project will total an estimated $4,000,000 over a 40-year period.

Income from taxes to local governments will be greatly enhanced as a result of Lake Limestone and the industrial development it will make possible in the area. The $225,000,000 estimated construction cost of the electric generating plant planned for Robertson County alone is almost fifteen times the total assessed tax value of $15,029,495 in Robertson County in 1970 (Texas Almanac, 1972-1973). Although the lands occupied by Sterling C. Robertson Dam and Lake Limestone will be in public ownership and not subject to local taxes, experience elsewhere clearly indicates that the increased values of private lands near the lake and associated with the growth that will be stimulated in area communities will far more than offset loss of taxes on the lands in the lake itself.

Lake Limestone will be open to the public for recreation and it is reported that the cooling lakes at the two power plants presently being planned will be also. Visitations to these facilities can be expected to bring a great deal of outside money into the local economy.

Summarizing then, the following direct benefits, which could reverse the adverse trends of recent decades in these three counties, would be lost to the economies of Limestone, Leon and Robertson Counties if Lake Limestone is not completed:

1. Additional payrolls amounting to some $319,000,000 over a 40-year period.

2. An increase of several hundred percent in the tax rolls of both Robertson and Limestone Counties.

3. The recreational opportunities that will be afforded by Lake Limestone and the two cooling lakes of the utility companies.

Lake Limestone will provide dependable water supplies in amounts 50% greater than the amounts required for the two power plants presently planned for construction in Limestone and Robertson Counties. The Authority is already engaged in negotiations with representatives of rural electric cooperatives wishing to contract for use of the remaining available water supplies from Lake Limestone, and it is almost certain that additional plants will be built in the area (most likely in Leon County) in order to use lignite as fuel for the thermal generation of electric energy. The economic benefits from added payrolls and increased tax values listed above should therefore be increased approximately 50%. However, if Lake Limestone is not completed, these added benefits would also be lost to the area economy.

The above analysis [illegible] that would result from preventing completion [illegible] was based upon the assumption that if water is not [illegible] the amounts needed for the generation of thermal electric [illegible] plants in the area where the fuel is located, then the fuel will be transported to where water is, or can be made, available for this purpose. However, at this time, no nearby location where this is the case is known to exist, and the costs of transporting lignite in the volumes needed for power generation are extremely great. It may therefore not be feasible to use the local area lignite at all if Lake Limestone is not completed. If indeed this were the case, then the local area economy would suffer the following additional direct losses:

1. An estimated additional $215,000,000 in payrolls for mining of lignite over a 40-year period.

2. Loss of lignite royalties totaling an estimated $88,000,000.

The losses discussed above [illegible] only the direct losses to the economies of the three county area of Limestone, Leon and Robertson Counties that would result from halting the completion of the Sterling C. Robertson Dam and Lake Limestone project. There would also be widespread losses and costs of almost incalculable magnitude to the people of the State and Nation. Even if some feasible plan is arrived at for transporting the lignite from the Navasota watershed to some other locality for use in generating electrical energy, the cost of the generated electricity will be much greater than if it can be used as now planned at the site where it is mined. These additional costs will fall directly on the millions of people in Texas served by the electrical utilities who must pay the costs that would be attendant to getting the fuel to use in this way. Indirectly, the people of the entire Nation would be burdened by the increased costs of goods produced in the area and distributed nationwide. The penalties to the people of the State and Nation would be even more severe if no feasible alternative can be found that would permit use of the energy resource represented by the presently unused lignite in the upper Navasota River watershed.

We appreciate the opportunity to furnish this additional information.

In making your determination with regard to the Brazos River Authority's application for a Section 404 permit, it is important that you have all the facts so that you may place in proper perspective the comments and recommendations you receive from others whose concerns are limited to narrow fields of interest that may be affected by Lake Limestone. This is particularly true of the

U. S. Fish and Wildlife Service's recommendation (set forth in the February 2, 1976 letter to you from Mr. R. F. Stephens, Acting Regional Director, U. S. Department of Interior Coordinator, Albuquerque) that our application for a permit be denied unless the Authority takes from private ownership twice as much land as required for Lake Limestone in order to provide 15,800 acres of land for wildlife management areas to accommodate the wildlife being displaced by the lake.

It is recognized that U. S. Fish and Wildlife Service comments on permit applications such as ours are made without regard for any factors other than the effects on fish and wildlife, and that it is not their function to consider any of the other factors involved. Quoting the Fish and Wildlife Service itself (40 Fed. Reg. P. 55810) "... The Service's role is to evaluate and comment on the effects of a proposal on fish and wildlife resources. It is the function of the regulating agency rather than the Fish and Wildlife Service to balance all factors...and decide which type of activity will be permitted."

We hope the additional information submitted herewith will be helpful to you in carrying out that function in regard to the Brazos River Authority's application for a Section 404 permit for its Lake Limestone project.

Sincerely,

WALTER J. WELLS
General Manager

WJW:dp
Encl.

cc: Director, Budget and Planning Office
Office of the Governor of Texas
Chairman, Texas Water Rights Commission
Executive Director, Texas Water Development Board
Executive Director, Texas Water Quality Board
Each Member, Board of Directors
Brazos River Authority

SUMMARY OF ESTIMATED FINANCIAL LOSS

Which would be incurred by the Brazos River Authority if construction of the proposed Sterling C. Robertson Dam and Lake Limestone Project should be halted on 1 July 1976 due to denial of Section 404 permit:

COSTS	
Project Construction Costs (money actually spent through 31 January 1976 plus money estimated to be spent by 1 July 1976):	$10,692,000
Interest Which Must be Paid on Bonds Thus Far Issued (1975 Series Revenue Bonds in the amount of $30,000,000 sold 19 June 1975) prior to earliest date on which bonds may be redeemed (April 1, 1980):	$10,139,000
Estimated Costs and Penalties for Materials and Equipment Committed to Project But Not Incorporated as of July 1, 1976:	$ 893,000
Estimated Contract Abandonment Costs (remaining value of costs of mobilization, etc. not recovered by Contractor by July 1, 1976):	$ 244,000
Estimated Site Restoration Costs:	$ 3,820,000
Total Costs:	$24,450,000
CREDITS AGAINST COSTS	
Estimated Net Salvage Value of Lands:	$ 3,121,000
Interest Earned On Project Funds:	4,557,000
Total Credits:	$ 7,678,000
TOTAL ESTIMATED NET FINANCIAL LOSS	$18,110,000

Attachment 1

IN REPLY REFER TO:

HP

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

POST OFFICE BOX 1306
ALBUQUERQUE, NEW MEXICO 87103

February 2, 1976

District Engineer
Corps of Engineers, U. S. Army
Post Office Box 17300
Fort Worth, Texas 76102

Dear Sir:

By Public Notice W-N-443-41-Permit-141, dated December 3, 1975, you advised this office of an application by the Brazos River Authority for a Section 404 Department of the Army permit to construct the Sterling C. Robertson Dam and Limestone Reservoir at river mile 124.5 on the Navasota River in Leon and Robertson Countries, Texas. The purpose of the project is to provide municipal, industrial, and agricultural water supply.

The revised Department of the Interior Manual Instructions (503 DM 1), dated August 3, 1973, assign responsibility for Department of the Interior coordination and review of Department of the Army permit applications to the U. S. Fish and Wildlife Service. In accordance with these instructions, we submit the following Departmental comments on the permit application.

This report was prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). It has been coordinated with representatives of the Texas Parks and Wildlife Department.

Project plans include an 8,000-foot earthen dam and a concrete reenforced spillway section with five 40- by 28-foot tainter gates. The dam will be equipped with multi-level lowflow outlets at elevations 322.0, 325.5, 339.0, and 352.0. The streambed elevation at the proposed dam site is 320 feet.

The impoundment will inundate 15 miles of the Navasota River. At conservation pool, elevation 363, the reservoir will have 14,200 surface acres and a capacity of 217,494 acre-feet. The dam and spillway will occupy 1000 acres. All low flows up to 6 cubic feet per second (cfs) will pass through the dam. Flows of less than 2 cfs will be supplemented by making releases of 2 cfs until such time as low flow ceases.

All lands to be inundated by the conservation pool will be purchased in fee title or flowage easement, depending upon owner preference. Lands above this elevation will remain in private ownership. However, five areas are proposed for purchase to provide public access to the reservoir.

The project lies in the upper reach of the Navasota River in the Post Oak Savannah Land Resource Area. Principal habitat types are bottomland forests and cleared bottomlands. The major woody species in the bottomland forests are pecan, post oak, water oak, willow oak, overcup oak, honey locust, hackberry, cedar elm, deciduous holly, yaupon, green brier, grapes, dewberry, possumhaw, and swamp privet. Major forbs are giant ragweed, smartweed, dock, croton, and sedge. Some common grass species in the bottomland forests are bermuda grass, Panicum species, Paspalum species, and bluestem. The cleared bottomlands are vegetated predominantly with grasses and forbs with a few scattered trees and shrubs.

Within the bottomland forests and cleared bottomlands there are approximately 9,300 acres of seasonally flooded wetlands (Type 1) and 700 acres of wooded swamps (Type VII). These wetland types are described in the Wetlands of the United States, U.S. Department of the Interior, Fish and Wildlife Circular 39.

Based upon seasonal flooding and the economic returns of additional clearing, it was assumed that all bottomland has been cleared that is practical to clear. Therefore, land use changes over the 100-year project evaluation period would be insignificant.

The area of project influence for aquatic life extends approximately 140 miles from the headwaters of the proposed impoundment to the mouth of the Navasota River. The river within the project area is a meandering turbid stream about 20 feet wide, interlaced with fallen trees but with little aquatic vegetation. The average flow for a nine-year period of record is 177 cfs, however no flow was recorded during certain periods in 1967, 1969, 1971 and 1972. There are about 30 ponds within the project area averaging approxiately one acre each. Most of the ponds are located near the elevation contour of the proposed conservation pool in the transition zone between upland and bottomland.

The project area is inhabited by numerous species of wildlife. Representative mammals include white-tailed deer, coyote, bobcat, raccoon, opossum, cottontail, and armadillo. The area's avifauna is characterized by numerous songbirds in addition to mallards, wood ducks, mourning doves, turkey vultures and great blue herons. The amphibian and reptilian population includes snakes (including cottonmouths), salamanders, sliders, and treefrogs. A significant

amount of hunting occurs in the project area as evidenced by numerous hunting and fishing camps.

The lake and dam will inundate or otherwise result in the destruction of 15,200 acres of wildlife habitat. Since the project is not designed to provide flood control, the effect on the wildlife habitat in the downstream floodplain should be minimal. The lake will provide some wintering resting habitat for waterfowl and because of the plans for leaving standing timber in certain areas of the reservoir, it will provide favorable habitat, at least for a few years, for wading birds and fur animals.

Fish inhabiting the project area waters are typical warmwater species including gizzard shad, gar, shiners, suckers, buffalo, catfish, crappie, freshwater drum, largemouth bass, and various sunfish. Fishing in the Navasota River is light and because of the lack of public access, angling activity is restricted primarily to landowners and their guests.

The upper end of the proposed reservoir will be shallow and provide spawning areas for certain fish species. Typical warmwater species such as largemouth bass, bluegill, channel catfish and carp are expected to inhabit the lake. With adequate public access to the lake, it would probably receive a moderate amount of fisherman use; however, much of the fishing on the reservoir will represent transfer use from other nearby reservoirs which currently provide adequate angling opportunities.

Since streamflow below 2 cfs will be supplemented by reservoir releases, the fishery habitat below the dam should be improved because of the increased stability. However, because of limited access, use of the stream is anticipated to remain the same as without the project.

An analysis of the project impact on fish and wildlife resources was conducted using a modification of the Ecological Planning and Evaluation Procedures in accordance with the Principles and Standards for Planning Water and Related Land Resources. The principal habitat types were evaluated and rated according to the importance of each type for fish and wildlife, thereby providing a unit measure of habitat loss and corresponding mitigation needs for cleared bottomland and bottomland hardwood forest. This analysis indicated that mitigation of project-induced habitat losses would require the acquisition and management of two areas having a total acreage of 15,800, as illustrated on Plate 1. These acreages would provide replacement for project losses of cleared bottomland. It would also provide partial compensation for the loss of bottomland forest.

This reservoir will be capable of producing a firm yield of 70,000 acre-feet of water annually for municipal, agricultural, and industrial purposes. Initially, local industrial needs will require about 25,000 acre-feet annually. Then the need for water will increase for future industrial, municipal, and agricultural purposes. Therefore, the possibility exists for incrementally filling the lake based upon short-term projections of demands. This mode of operation would decrease the annualized habitat losses and possibly offset losses of bottomland forest which would not be fully compensated by the proposed land acquisition.

The project should be operated to allow for a gradual increase in downstream flows as opposed to high volume short term releases. This measure, along with the guaranteed low-flow, would provide for the maintenance of a higher quality downstream fishery, and result in increased stream stability.

In view of the expected project-induced losses to fish and wildlife resources and their associated habitat, the Department of the Interior recommends that the permit be denied unless the following modifications are included as conditions of the permit:

1. Acquire 15,800 acres of land in fee title, adjacent to the project area as shown on the attached plate. These mitigation areas shall be made available through suitable agreements to the Texas Parks and Wildlife Department for administration as wildlife management areas.

2. The lake shall be filled incrementally to meet short-term projections of water demands.

3. The project shall be operated to provide low volume downstream releases rather than short term high volume releases.

Sincerely yours,

R. F. Stephens

Acting Regional Director
U. S. Department of the
Interior Coordinator

Enclosure

cc: w/enc.
Executive Director, Texas Parks and Wildlife Dept., Austin, Texas
Commissioner, General Land Office, Austin, Texas
Regional Director, Bureau of Outdoor Recreation, Albuquerque, N. Mex.
Regional Administrator, Environmental Protection Agency, Dallas, Texas
Field Supervisor, FWS, Div. of Ecological Services, Fort Worth, Texas

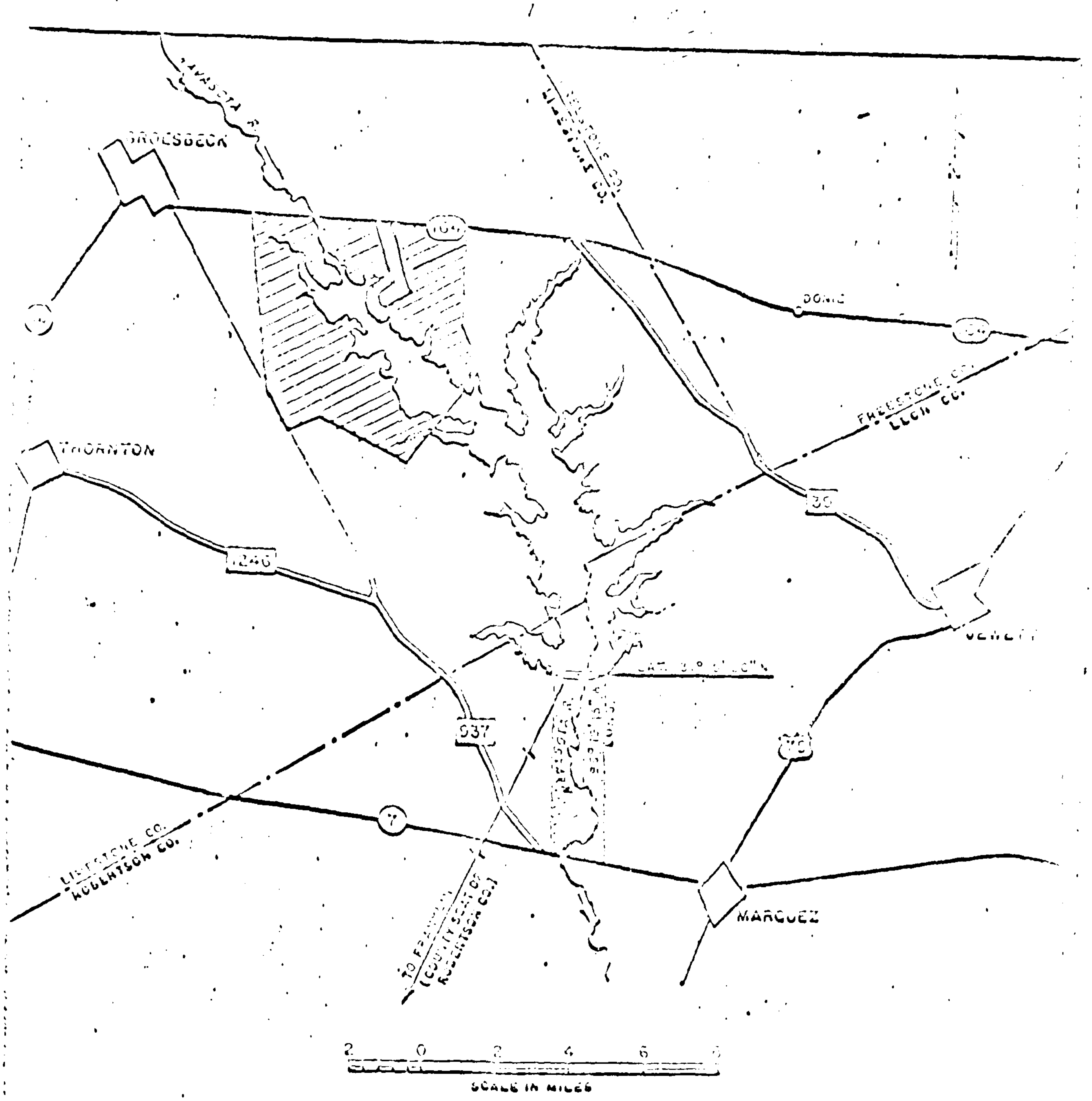


Plate 1. VICINITY MAP

Mitigation Area

STERLING C. ROBERTSON JR.

NAVASOTA RIVER

(RIVER MILE 124.5)

ROBERTSON AND LEON COUNT...

APPLICATION BY BRAZOS R.A.

TEXAS WATER RIGHTS COMMISSION

STEPHEN F. AUSTIN STATE OFFICE BUILDING

January 6, 1976

P.O. Box 13207
Austin, Tx 78711

Brigadier General James M. Rose
Director, Division of Planning Coordination
Office of the Governor
411 West 13th Street
Austin, Texas 78701

Attention: Mr. Wayne N. Brown

Re: Corps of Engineers, Fort Worth District -- Public Notice of Application by the Brazos River Authority for a Permit Under Section 404, Public Law 92-500, Relative to Construction of Sterling C. Robertson Dam-Lake Limestone, Leon and Robertson Counties, Texas. (Reference: SWFOD-R; W-N-443-41-Permit-141.) December 3, 1975.

Dear General Rose:

As requested in your letter of December 10, 1975, the staff of the Texas Water Rights Commission has considered the referenced Public Notice and offers the following comments:

1. On October 1, 1974, the Texas Water Rights Commission issued to the Brazos River Authority, all in accordance with the Texas Water Code and the Rules and Regulations of the Commission, Permit No. 2950 authorizing the Brazos River Authority to construct the referenced dam and reservoir project on the Navasota River and to impound State water therein not to exceed 217,494 acre-feet at 363 feet above mean sea level. The permittee was authorized to include the said reservoir in its reservoir system operation as authorized by the Commission's Order of July 23, 1964, as amended. The said permit includes specific, special conditions relative to:

   a. Required passage of water through the dam at all times, including the period of construction and initial filling of the reservoir.

b. Pre-impoundment measurements to develop an acceptable correlation between low flows upstream from the reservoir and low flows at the dam site; and the specific rates and conditions of low-flow releases.

c. Continuous measurement of reservoir level; and periodic records of reservoir content, low-flow releases, and the quantities and uses of releases to be charged against the water priority right of the said reservoir, or to be charged against the Brazos River Authority reservoir system.

d. Survey and monumentation of sediment ranges and the development and maintenance of useful elevation-area-capacity tables.

2. On May 7, 1975, the Texas Water Rights Commission issued an Order approving the final plans and specifications for construction of Sterling C. Robertson Dam under Permit No. 2950 of the Brazos River Authority. The Order further provided that the construction work shall be under the continuous supervision of the permittee's consulting engineer who shall make periodic reports of construction progress to the Commission.

3. It is made clear in the provisions of Permit No. 2950, that the said reservoir project is permitted by the Texas Water Rights Commission as an element of the Brazos River Authority's basin-wide system of reservoirs and is to be operated as such not only to meet water needs in the local area of the reservoir but also to help meet water needs downstream in the Brazos River Basin and adjoining coastal areas south of Houston.

4. The urgency of need for the said reservoir is emphasized by the fact that the long-range dependable yield of the existing reservoirs in the Authority's basin-wide system is essentially committed, and additional water needs can be met only through construction of additional water supply reservoirs. Hence, the Commission considers undelayed construction

of the Sterling C. Robertson Dam-Lake Limestone project a matter of urgent public necessity. Consequently, the Commission urges that the Corps of Engineers and the Environmental Protection Agency take necessary measures to expedite action on the issuance of the Section 404, P. L. 92-500 permit. The cost-inflation impacts of any delays in a construction project underway is cause for great concern.

The above comments are furnished with constructive, yet emphatic intent to facilitate and expedite action by the Corps of Engineers and the Environmental Protection Agency under Section 404, P. L. 92-500. Substantial data relative to the resources, environment, and ecosystems of the Navasota River Basin are available from the State water agencies as a consequence of recently-completed studies and investigations relating to the Navasota and Millican reservoir projects. If you have any questions on these review comments, please notify Dr. Alfred J. D'Arezzo, Special Analyst for Environment and Interagency Coordination, telephone (512)475-2678.

Sincerely,

Robert E. Schneider

RES-AJD:ll

Robert E. Schneider
Executive Director

ccs: District Engineer, Fort Worth District
Brazos River Authority
Texas Water Development Board
Texas Water Quality Board
Texas Water Rights Commission:
Mr. A. E. Richardson
Mr. Timothy L. Brown

COMMISSION
[illegible] CHAIRMAN
[illegible]
[illegible]

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
AUSTIN, TEXAS 78701

ENGINEER DIRECTOR
B. L. DEBERRY

December 18, 1975

SUBJECT: Sterling C. Robertson Dam and Lake Limestone
in Robertson, Leon and Limestone Counties
(Department of the Army Permit No. W-N-443
-41-PERMIT-141)

[illegible] D-5

District Engineer
Department of the Army
Fort Worth District, Corps of Engineers
P. O. Box 17300
Fort Worth, Texas 76102

Dear Sir:

We are in receipt of a public notice dated December 3, 1975 advising that the Brazos River Authority has applied for a Department of the Army permit authorizing the construction of Sterling C. Robertson Dam at River Mile 124.5 on the Navasota River in Leon and Robertson Counties, Texas. The impoundment which will be formed by the dam, identified in the notice as Lake Limestone, may require adjustments to F.M. 1512 at the site of the Lambs Creek crossing, a finding which is based on preliminary data and information previously furnished by the applicant. Although detailed planning for necessary adjustments to the structure and approaches would be somewhat premature at this stage of project development, we believe you should be aware of the possible secondary effects of the proposed [illegible] construction and recommend that the scope of authority granted in the permit be broadened to include any subsequent adjustment of highway facilities which might be directly attributable thereto. This would include compliance with the requirements of Section 404 of the Federal Water Pollution Control Act Amendments of 1972.

Your earnest consideration and approval of this request would be ap[illegible]

Sincerely yours

B. L. DeBerry
Engineer-Director

By: Wayne Hennebergerwh

Wayne Hennebe[illegible]r

TEXAS WATER DEVELOPMENT BOARD

HARRY P. [illegible]
EXECUTIVE [illegible]

P.O. BOX 13087
CAPITOL STATION
AUSTIN, TEXAS 78711

AREA CODE 512
475-3581
1700 NORTH CONGRESS

December 15, 1975

IN REPLY REFER TO
TAB[illegible]

General James M. Rose, Director
Division of Planning Coordination
Office of the Governor
Executive Office Building
411 W. 13th Street
Austin, Texas 78701

Dear Jim:

We have reviewed the Public Notice issued by the Corps of Engineers relative to the application by the Brazos River Authority for a permit, under Section 404 of P.L. 92-500, to construct the Sterling C. Robertson Dam-Lake Limestone project on the Navasota River in Leon and Robertson Counties, Texas.

The above-mentioned reservoir is an urgently-needed project for municipal and industrial water supply purposes. Water supplies allocated for industrial purposes, under provisions of the permit issued by the Texas Water Rights Commission, are needed at the earliest possible date for steam electric power plant cooling purposes at the Steele Creek and Duck Creek power plants -- soon to be completed. In our opinion, it is indeed unfortunate that this reservoir project, which is in the construction stage, must be subjected to the Corps recently-promulgated Section 404 rules and regulations and companion guidelines established by the Environmental Protection Agency.

This agency supports implementation of this project and urges the Corps of Engineers to complete the environmental impact statement preparation and review process as expeditiously as possible. Substantial data and information relative to the

resources, environment, and ecosystems of the Navasota River Basin are available as a consequence of recently-completed studies and investigations relating to the Navasota and Millican projects. All information in our files relevant to this project are readily available to the Corps and EPA upon request.

It is our sincere hope that completion of the project will not be unduly delayed as a consequence of processing of the Section 404 permit application and procedures associated with preparation and review of the environmental impact statement.

Sincerely,

Harry P. Burleigh

cc: District Engineer
Ft. Worth District
Corps of Engineers

Brazos River Authority

BRAZOS RIVER AUTHORITY

4400 COBBS DRIVE P. O. BOX 7555 TELEPHONE AREA CODE 817 776-1441
WACO, TEXAS 76710

January 14, 1976

District Engineer
Fort Worth District
U. S. Army Corps of Engineers
P. O. Box 17300
Fort Worth, Texas 76102

Dear Sir:

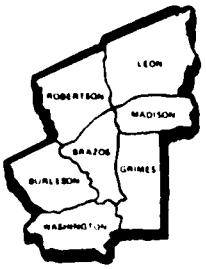
Forwarded herewith is a Resolution of the City Council of the City of Calvert concerning the Brazos River Authority's application for a Section 404 Permit for Sterling C. Robertson Dam which was apparently misdirected to Brazos River Authority rather than to the Fort Worth District. Please make this a part of the record in response to the Public Notice dated 3 December 1975 relative to our application.

Very truly yours,

Carson H. Hoge

CARSON H. HOGE
Assistant General Manager

CHH:bb
Encl.



BRAZOS VALLEY DEVELOPMENT COUNCIL
P. O. DRAWER 4128 • BRYAN, TEXAS 77801

January 8, 1976

District Engineer
Fort Worth District Corps of Engineers
P. O. Box 17300
Fort Worth, Texas 76102

Dear Sir:

The Brazos Valley Development Council is a Regional Planning Commission, organized under provisions of Chapter 570, Acts, 59th Legislature, Regular Session, 1965, (codefied as Article 1011m, V.A.C.S.), and an Economic Development District orgainzed under the Public Works and Economic Development Act of 1965, has been given the responsibility of Areawide Comprehensive Planning by both State and Federal agencies.

The Council supports the construction of the Sterling C. Robertson Dam and creation of Lake Limestone by the Brazos River Authority as shown by the attached resolution adopted January 8, 1976.

Please consider this letter and the resolution as a part of your support documents in granting the permit to the Brazos River Authority.

Very truly yours,

Glenn J. Cook
Executive Director

GJC/dfh

Enclosure as stated

RESOLUTION

WHEREAS, the Brazos River Authority, a public agency of the State of Texas charged by the State with responsibility for conserving, developing and making available for beneficial utilization the surface waters of the Brazos Basin, is constructing the Sterling C. Robertson Dam to create Lake Limestone on the Navasota River in Robertson, Leon and Limestone, County, Texas; and;

WHEREAS, a portion of the water supply that will be available from Lake Limestone will be used immediately to make possible the beneficial utilization of a presently unused energy resource lignite to generate electrical energy; and;

WHEREAS, the electrical energy that will be generated using presently unused lignite resources is urgently needed by the people of the State and nation and could not be made available without water from Lake Limestone; and;

WHEREAS, an additional supply of water will be made available from Lake Limestone and can be utilized for future development of energy resources and could benefit persons in the local area and in other areas of the Brazos Basin; and;

WHEREAS, Lake Limestone and the other development associated therewith would create one thousand temporary jobs during the five-year construction period and up to four hundred permanent jobs thereafter in an area designated as a redevelopment area under the Public Works and Economic Development Act of 1965, as amended; and;

WHEREAS, revenues to local units of government will be significantly increased as a result of the general enhancement of values and the addition of significantly taxable assets in the local area associated with the Lake Limestone development; and;

WHEREAS, under the ownership of the Brazos River Authority, a public agency, the waters of Lake Limestone will be open to the public and will furnish water-oriented recreation to many thousands of people annually in an area previously entitled under private ownership and available for recreation only to the land owners and to their lessees; and;

WHEREAS, the Brazos River Authority is now required under regulations promulgated to enforce Section 404 of Public Law 92-500 to obtain a permit for the Sterling C. Robertson Dam from a Corps of Engineers by July 1, 1976; and;

WHEREAS, the Sterling C. Robertson Dam and Lake Limestone project and related development have been fully explained in public meetings and through releases in the news media, and the response of area citizens is overwhelmingly favorable to the project:

NOW, THEREFORE, BE IT RESOLVED, by the Brazos Valley Development Council that the Corps of Engineers is urgently requested to make a favorable finding and issue a permit to the Brazos River Authority for Sterling C. Robertson Dam and Lake Limestone under Section 404 of Public Law 92-500 so that this critically needed project may be completed without delay.

I CERTIFY THAT the above Resolution was adopted by the Board of Directors of the Brazos Valley Development Council, duly assembled on the 8th day of January, 1976, and that said Resolution is in the minutes of said meeting.

F. L. Thompson

F.L. Thompson
Chairman of the Board

ATTEST:

William R. Vance

Judge William R. Vance
Secretary of the Board

CHAMBER OF COMMERCE

FRANKLIN, TEXAS 77856

P. O. Box 126 Telephone 828-3276

January 16, 1976

District Engineer
Fort Worth District, Corps of Engineers
P.O. Box 17300
Fort Worth, Texas 76102

Re: Brazos River Authority Application for Permit, Sterling C. Robertson Dam

Gentlemen:

This letter is being submitted as an official action of the Board of Directors of the Franklin Chamber of Commerce and in response to the Public Notice issued by the Fort Worth District of the Corps of Engineers relative to the application of Brazos River Authority for a Department of Army permit for construction of the Sterling C. Robertson Dam.

Through local public meetings and news releases carried by the news media of the area, we are aware that Brazos River Authority is presently constructing Sterling C. Robertson Dam to create Lake Limestone on the Navasota River in Leon, Robertson and Limestone Counties, Texas. The Chamber is also aware tnat a portion of the water to be impounded is to be used in the near future to make possible the operation of electrical power generating facilities utilizing a presently unused energy source, lignite.

These developments are considered by this Chamber of Commerce to be of substantial economic benefit to the entire area. Not only are revenues to local governmental entities expected to be increased significantly due to the addition of significant taxable assets and the general enhancement of values in the local area, construction of Sterling C. Robertson Dam and the other developments related to Lake Limestone will create up to 1,000 temporary jobs during the five-year construction period and up to 400 permanent jobs thereafter.

CHAMBER OF COMMERCE

FRANKLIN, TEXAS 77856

P. O. Box 126 Telephone 828-3276

In addition to the above benefits, other water from Lake Limestone will be available for utilization in the further development of energy resorces and for other beneficial purposes in the local areas and in other areas of the Brazos Basin. Also, under the ownership of the Brazos River Authority which is a public agency, the waters of Lake Limestone will be open to the public and will undoubtedly be used for water-oriented recreation by thousands of people each year.

In the judgment of this body, and in view of the overwhelmingly favorable response of the public, the benifits to the public of the Lake Limestone project far outweigh any possible adverse effects of the project. It is therefore urged that the project be determined by the Corps of Engineers to be in the public interest and that the Department of the Army permit requested by the Brazos River Authority be granted at the earliest possible time.

Very truly yours,

Coleman Rhodes

Coleman Rhodes
President, Franklin Chamber of Commerce, Franklin, Tx.

Chamber of Commerce

Groesbeck, Texas 76642

January 9, 1976

Department of the Army
Fort Worth District, Coops of Engineers
P.O. Box 17300
Fort Worth, Texas 76102

Dear Sir:

In its regular meeting of January 8, 1976, the Groesbeck Chamber of Commerce adopted the attached resolution supporting construction of the Sterling C. Robertson Dam and Lake Limestone on the Navasota River.

It is our opinion that this project will be a valuable boost to the economy and the recreational opportunities of Groesbeck and south Limestone county, and that a vast majority of the people of this area heartily support it and are anxious to see it completed.

Yours truly,

Gary Vogel

Gary Vogel
President

GV:bl

Enc:

Chamber of Commerce

Groesbeck, Texas 76642

Resolution Adopted by Chamber of Commerce, Groesbeck, Texas
January 8, 1976

WHEREAS, Lake Limestone, an impoundment which will be created in Limestone, Leon and Robertson Counties by Sterling C. Robertson Dam on the Navasota River, will furnish water supplies to meet municipal, industrial and agricultural needs as they develop in the local area and in other areas of the Brazos Basin and;

WHEREAS, a portion of the water supplies from Lake Limestone will be used immediately to make possible the utilization of presently unused lignite resources for the generation of electrical power to serve the growing needs of the people and industries of this state and nation, including those industries engaged in the manufacture of farm equipment needed to grow, harvest and process food to feed the increasing populations of the world; and

WHEREAS, the need for additional local employment is recognized, and Lake Limestone and other developments associated therewith will create up to 1,000 temporary jobs during the five-year construction period and up to 400 permanent jobs; and

WHEREAS, the need for additional recreational facilities in our area is realized, and under the ownership of the Brazos River Authority, a public Agency, the waters of Lake Limestone will be open to the public and will provide water-oriented recreation to many thousands of people annually;

BE IT RESOLVED that the Groesbeck Chamber of Commerce does therefore go on record as endorsing the construction of Sterling C. Robertson Dam and Lake Limestone on the Navasota River in Leon, Robertson and Limestone Counties, and urges the Corps of Engineers to issue the Department of the Army permit requested by Brazos River Authority for such construction.

R. W. OLIVER, JR.
Mayor

MRS. MARTHA TILLEY
City Secretary

CITY OF GROESBECK

GROESBECK, TEXAS 76642

January 15, 1976

Corps of Engineers
District Engineer
P.O. Box 17300
Fort Worth, Texas 76102

Gentlemen:

Enclosed please find a Resolution passed by the City Council of the City of Groesbeck on January 13, 1976. This Resolution endorses the Sterling C. Robertson Dam and Lake Limestone as being in the public interest and urges the Corps of Engineers to issue any needed permits so that construction can be continued and speedily completed.

Please make this Resolution a part of the record. Thank you.

Sincerely,

Martha Tilley
(Mrs.) Martha Tilley
City Secretary

MT:s

Enc.

City of Calvert

Calvert, Texas

January 7, 1976

RESOLUTION

WHEREAS, the Brazos River Authority, a governmental agency of the State of Texas, is now constructing the Sterling C. Robertson Dam to create Lake Limestone on the Navasota River in Robertson, Leon and Limestone Counties, [illegible] and

WHEREAS, supplies of water will be available from Lake Limestone for use in the development of energy resources and for other beneficial purposes in the local area and in other areas of the Brazos Basin; and

WHEREAS, some of the water supply that will be available from Lake Limestone is urgently needed to make possible the utilization of a presently unused resource, lignite, to generate electrical energy and help alleviate the current and anticipated energy shortage being experienced by the State and the Nation; and

WHEREAS, Lake Limestone and the facilities to which it will supply water initially will create up to 1,000 temporary jobs during the five-year construction period and up to 400 permanent jobs thereafter; and

WHEREAS, the economy of the area will be improved and revenues to local units of government substantially increased as a results of the general enhancement of values and the addition of significant taxable assets in the local area; and

WHEREAS, the waters of Lake Limestone will be open to the public, thus providing water-oriented recreation to thousands of people annually in an area previously held in private ownership; and

WHEREAS, the Brazos River Authority is now required under regulations promulgated to enforce Section 404 of Public Law 92-500 to obtain a Federal Government permit for Sterling C. Robertson Dam from the Corps of Engineers;

NOW THEREFORE, be it resolved by the City Council of the City of Calvert, Texas that the Corps of Engineers if urged to find that the project is in the public interest and to issue a permit to Brazos River Authority for Sterling C. Robertson Dam under Section 404 of Public Law 92-500.

Cooper Wiess, Mayor, City of Calvert

John W. Anderson

Lola B. Griffin

Robert Comfort

[illegible]

State of Texas

COUNTY OF LEON

Centerville, Texas 75833

December 30, 1975

Department of the Army
Fort Worth District, Corps of Engineers
P.O. Box 17300
Fort Worth, Texas 76102

Re: Brazos River Authority Application for Permit

Dear Sirs:

The Commissioners' Court of Leon County has discussed several times the proposed Lake Limestone. We are very much in favor of the Brazos River Authority receiving the Corps of Engineers Department of the Army Permit. We believe that construction of the Sterling C. Robertson Dam, to form Lake Limestone, will be for the good of our people in Leon County. We feel it wil be a good recreational lake, and may help bring some Industry to our County. We believe it will help prevent flooding below the Lake and see no environmental damages this Lake would cause to the land, or people of our County.

Yours truly,

James O. Hill

James O. Hill,
County Judge

JOH:mb

City of Jewett

INCORPORATED SEPT. 1, 1890

JEWETT, TEXAS

DRAFT
January 12, 1976

District Engineer
Fort Worth District Corps Of Engineers
P.O. Box 17300
Fort Worth, Texas 76102

WHEREAS, Brazos River Authority, a governmental agency of the State of Texas, is constructing the Sterling C.Robertson Dam to create Lake Limestone on the Navasota River in Leon, Robertson and Limestone Counties, Texas ; and

WHEREAS, a portion of the water supply that will be available from Lake Limestone is urgently needed to make possible the utilization of a presently unused resource, Lignite, to generate electrical energy and help alleviate the current and anticipated energy shortage being experienced by the State and and Nation; and

WHEREAS, additional supplies of water will be available from Lake Limestone and can be utilized for further development of energy resources and for other beneficial purposes in local areas and in other aereas of the Brazos Basin; and

WHEREAS, under the ownership and operation of the Brazos River Authority the waters of Lake Limestone will be open to the public and will furnish water-oriented recreation to many thousands of people annually in an area previously held entirely in private ownership and not open to the public;

NOW THEREFORE, be it resolved that the City Council of the City of Jewett endorses the Sterling C. Robertson Dam and Lake Limestone project as being in the public interest and urges the issuance of permit for same pursant to Section 404 of Federal Water Pollution Control Act Amendments of 1972

Sam A. Wingfield, Mayor

Robert M.Christian, Councilman

Joe H. Holmes, Councilman

E.J. Chapman, Councilman

Jim Salley, Councilman

Keneth Turner, Councilman

CITY OF JEWETT
P.O.BOX 188
JEWETT, TEXAS 75846

City of Franklin

A General Law City

FRANKLIN, TEXAS 77856

P. O. Box 428 (713) 828-3257

January 20, 1976

RESOLUTION

WHEREAS, Sterling C. Robinson Dam, now under construction by the Brazos River Authority on the Navasota River will create lake Limestone in Robertson, Leon and Limestone Counties, Texas; and

WHEREAS, water supplies from lake Limestone will make possible the use of presently unused lignite resources in this area to help meet urgent energy needs and will be available for utilization for other beneficial purposes in this and other areas of the Brazos Basin; and

WHEREAS, Lake Limestone will be a major public recreational facility, providing water-oriented recreation opportunities to many thousands of people annually; and

WHEREAS, because of these water supply and recreational benifits Lake Limestone will significantly benifit the economy, and greatly enhance the human environment of the area; and

WHEREAS, the City of Franklin has already expressed its official endorsement and support of Sterling C. Robertson Dam and Lake Limestone at the public hearing before the Texas Water Rights Commission in connection with issuance to the Brazos River Authority of a State permit for the project; and

WHEREAS, under recently promulgated regulations, the Brazos River Authority must now obtain a Department of the Army permit for the project from the Corps of Engineers;

NOW THEREFORE, be it resolved that the City of Franklin fully endorses the Sterling C. Robertson Dam and Lake Limestone Project as being in the best interests of the public and urges that all necessary permits for it be issued without delay so that its construction can be completed without interruption.

ATTEST

Alvin Niemann

ALVIN NIEMANN CITY SECRETARY

Prise Metcalfe

PRISE METCALFE MAYOR

Mexia Chamber of Commerce

MEXIA, TEXAS 76667

PHONE 562-3761
P. O. BOX 352

1-20-76

District Engineer
Ft. Worth District, Corps of Engineers
P.O.Box 17300
Ft. Worth, Texas 76102

Gentlemen:

This statement is submitted in response to your Public Notice relative to the application of Brazos River Authority for a Department of the Army permit for Sterling C. Robertson Dam on the Navasota River in Leon and Robertson Counties, which will create an impoundment to be known as Lake Limestone in Leon, Robertson and Limestone Counties, Texas.

This Chamber has been kept informed and has assisted the Brazos River Authority inform the public by sponsoring a public meeting at which the Authority explained the scope and purposes of this project. On the basis of the information thus furnished us, we understand that this will be a water supply project of the Brazos River Authority, a public agency of the State of Texas. The water impounded will therefore be available to meet needs which exist or may develop in the local area and in other areas of the Brazos Basin.

We are also aware that a portion of the water supply that will be available from Lake Limestone will be used in the immediate future to make possible the construction and operation of electric power generating facilities which will be fueled with lignite, a presently unused energy source found in some parts of this area. This additional electric power is urgently needed throughout the State and Nation.

Construction of the Sterling C. Robertson Dam and the development of other projects dependent upon Lake Limestone will result in a substantial economic benefit to the entire area. In addition to the estimated 350 to 400 permanent jobs to be created, the addition of desirable taxable assets in the local area will increase revenues to local units of government.

Under the ownership and operational control of Brazos River Authority, the waters of Lake Limestone will be open to the public and will provide water-oriented recreation for thousands of people each year. This addition to the outdoor recreational opportunities of this area is locally considered to be a highly desirable enviornmental benefit.

On the basis of the above factors, the Mexia Chamber of Commerce considers the Sterling C. Robertson Dam project to be in the public interest, and by official action of its Board of Directors, hereby urge the Corps of Engineers to issue the permit for it requested by Trinity River Authority so that this very desirable project may be completed without interruption.

Very truly yours

Mexia Area Chamber of Commerce

N.J. Kensey
Manager

RESOLUTION

WHEREAS, the Corps of Engineers has issued a public notice stating that the Brazos River Authority has applied for a Department of the Army permit that is now required for Sterling C. Robertson Dam, which the Authority is in the process of constructing on the Navasota River closely downstream from the southern boundary of Limestone County, Texas; and

WHEREAS, Lake Limestone, which Sterling C. Robertson Dam will create in Limestone, Leon and Robertson Counties, Texas, will provide water to supply an array of beneficial purposes in the local area and elsewhere in the Brazos Basin; and

WHEREAS, a portion of this water supply will be put to use immediately to make possible the generation of urgently needed electrical power using lignite from local deposits, a presently unused energy resource; and

WHEREAS, additional supplies of water will be available to meet other needs in the local area and elsewhere in the Brazos Basin; and

WHEREAS, under the ownership of the Brazos River Authority, a governmental agency of the State of Texas, the waters of Lake Limestone will be open to the public and will be a major recreation facility, providing water based recreation to many thousands of people per year; and

WHEREAS, the economic and recreational benefits that will accrue from the Sterling C. Robertson Dam and Lake Limestone Project will greatly benefit the local economy and enhance the local human environment; and

WHEREAS, the project has been thoroughly explained in area public meetings and news media, and the City of Groesbeck has previously expressed its support for the project;

NOW THEREFORE be it resolved by the City Council of the City of Groesbeck that the City fully endorses Sterling C. Robertson Dam and Lake Limestone as being in the public interest and urges the Corps of Engineers to issue any needed permits so that the construction of this much needed project may be completed without delay.

PASSED AND APPROVED this the 13th day of January A.D., 1976.

Mayor

ATTEST:

City Secretary

RESOLUTION

WHEREAS, The Brazos River Authority, a public agency of the State of Texas, is now constructing Sterling C. Robertson Dam on the Navasota River in Leon and Robertson Counties to create Lake Limestone in Limestone, Robertson and Leon Counties, Texas; and

WHEREAS, water supplies will be available from Lake Limestone for beneficial purposes in the local area and in other areas of the Brazos Basin; and

WHEREAS, a portion of the water supply that will be available from Lake Limestone will be used immediately to make possible the beneficial utilization of a presently unused energy resource, lignite, to generate electrical power urgently needed by the people of this State and Nation; and

WHEREAS, construction of Sterling C. Robertson Dam and of other developments that will be made possible by availability of water supplies from Lake Limestone will create many additional jobs and provide many other substantial economic benefits to the entire area; and

WHEREAS, Lake Limestone will be owned and operated by a public agency so that it will be open to the public for water-oriented recreational use thereby providing additional recreation opportunities to many thousands of people annually; and

WHEREAS, the Corps of Engineers has issued a public notice stating that the Brazos River Authority has applied for a Department of the Army permit which it must now obtain for Sterling C. Robertson Dam;

NOW THEREFORE, be it resolved by the City Commission of the City of Mexia that the Corps of Engineers is urged to find that construction of Sterling C. Robertson Dam is in the public interest and to issue the requested permit without delay so that this highly beneficial project can be completed without interruption.

PASSED AND APPROVED this the 20th day of January, 1976 upon a motion by Commissioner Farris, seconded by Commissioner Sewell, and upon a vote, 4 members

voting "AYE", and 0 members voting "NAY".

James A. Stanford
Mayor Pro Tem

ATTEST:

Mary Sealy
City Secretary

CITY OF KOSSE
P.O. Box 116
KOSSE, TX. 76653.

WHEREAS, the Brazos River Authority, a governmental agency of the State of Texas, is now constructing the Sterling C. Robertson Dam to create Lake Limestone on the Navasota River in Robertson, Leon and Limestone Counties, Texas; and

WHEREAS, a portion of the water supply that will be available from Lake Limestone is urgently needed to make possible the utilization of presently unused lignite deposits to generate electrical energy and help alleviate the current and anticipated energy shortage being experienced by the State and Nation; and

WHEREAS, other supplies of water from Lake Limestone will be available for other beneficial uses in the local area and in other areas of the Brazos Basin; and

WHEREAS, the waters of Lake Limestone will be open to the public and will provide water-oriented recreation to thousands of people annually; and

WHEREAS, a substantial economic benefit will accrue to the area as a result of increased employment opportunity and the addition of significant taxable assets of facilities to which water will initially be supplied from Lake Limestone;

NOW THEREFORE, be it resolved by the City Council of City of Kosse that the Corps of Engineers be urged to find that the Lake Limestone project is in in the public interest and to issue a permit to Brazos River Authority for construction of Sterling C. Robertson Dam.

O. N. Irwin

O. N. Irwin
Mayor Pro Tem

Audrey Whaley

Audrey Whaley
City Secretary

ROBERTSON COUNTY

FRANKLIN, TEXAS 77856

January 21, 1976

Department of the Army
Fort Worth District
Corps of Engineers
P. O. Box 17300
Fort Worth, Texas 76102

Dear Sir:

Be it resolved that the Robertson County Commissioners Court met in special session on January 21, 1976, and passed the enclosed resolution.

Very truly yours,

Wesley Eugene Peyton
County Judge

WEP:lkm
Enc.

ROBERTSON COUNTY

FRANKLIN, TEXAS 77856

RESOLUTION

January 21, 1976

WHEREAS, under recently adopted Federal regulations, the Brazos River Authority, a public agency of the State of Texas, must obtain a permit from the Corps of Engineers for the Sterling C. Robertson Dam which the Authority has under construction on the Navasota River in Robertson and Leon Counties; and

WHEREAS, water supplies from Lake Limestone, which Sterling C. Robertson Dam will impound in Robertson, Leon and Limestone Counties, will be available for beneficial use in the local area and elsewhere in the Brazos Basin; and

WHEREAS, a portion of the water supply from Lake Limestone will be put to immediate use in connection with the utilization of local lignite resources to provide urgently needed electrical energy; and

WHEREAS, in addition to the economic benefits that will result from the availability of water supplies from the lake and the developments that will be possible because of this availability, Lake Limestone will be open to the public for recreational purposes and will greatly enhance the outdoor recreation opportunities available to the public in this area;

NOW THEREFORE, be it resolved that the Commissioners' court of Robertson County, Texas, considers the Brazos River Authority's Sterling C. Robertson and Lake Limestone Project to be in the public cont.

interest and urges the Corps of Engineers to issue the permit needed to allow completion of this very desirable project without delay.

ATTEST:

Katherine Galloway
County Clerk

Wesley Eugene Peyton
County Judge

Oliver Burns
Commissioner Precinct #1

Alvis "Bully" Bishop
Commissioner Precinct #2

Doyal O. Caldwell
Commissioner Precinct #3

Bennett Hearne
Commissioner Precinct #4

THE STATE OF TEXAS)

THE COUNTY OF LIMESTONE)

I, Molly Sealy, Secretary of the City of Mexia, Limestone County, Texas, do hereby certify that the attached is a true and correct copy of a Resolution styled:

RESOLUTION SUPPORTING BRAZOS RIVER AUTHORITY PROJECT - STERLING C. ROBERTSON DAM ON LAKE LIMESTONE

which was duly passed and approved at a regular meeting of the City Commission of said City on the 20th day of January, 1976, showing those present and the motions and votes made and taken in connection with said Resolution.

Witness my hand and seal of said City this the 20th day of January, 1976.

Molly Sealy
City Secretary

SEAL:

COMMISSIONER'S COURT

BE IT REMEMBERED THAT ON THE 12th day of January, A. D., 1976, there came on and was held a REGULAR MEETING of the Commissioner's Court with the Honorable Calvin Hardison, County Judge presiding and with Commissioner's Ray Sealy, Floyd Lowry, Guy Durham, Elijah Black and Dena Pruitt County Clerk all present when the following orders were passed to-wit:

MOTION by Durham, seconded by Black, vote unanimous to accept the following Resolution.

WHEREAS the Brazos River Authority, a public agency of the State of Texas, presently has under construction the Sterling C. Robertson Dam which will create Lake Limestone on the Navasota River in the counties of Leon, Limestone and Robertson, Texas, and

WHEREAS a portion of the water supply which will be available from Lake Limestone will make possible the use of presently unused deposits of lignite to generate urgently needed electrical power, and

WHEREAS additional water will be available from Lake Limestone to meet other local and downstream needs as they develop, and

WHEREAS, the availability of these water supplies and the beneficial utilization of presently unused local natural resources will substantially enhance the economy of this area, and

WHEREAS, because its waters will be open to the public for recreational use, Lake Limestone will, in addition to the economic benefits it will provide, be a major public recreation facility and greatly increase the outdoor recreation opportunities available to the public in this area;

NOW THEREFORE, be it resolved that the Commissioners' Court of Limestone County, Texas urges the issuance of a permit pursuant to Section 404 of the Federal Water Pollution Control Act Amendments of 1972 as being in the public interest.

THE STATE OF TEXAS
COUNTY OF LIMESTONE

I, Dena Pruitt, County Clerk in and for the County Court of Limestone County, Texas, do hereby certify that the above and foregoing is a true and correct copy of the Order passed by Commissioner's Court on January 12, 1976, as same appears from the original instrument on file in this office in the Minutes of Commissioner's Court Record.

GIVEN UNDER MY HAND AND SEAL OF OFFICE, at Groesbeck, Texas, this 23rd day of January, A. D., 1976.

DENA PRUITT, County Clerk
Limestone County, Texas.

By Deborah Hoodrick Deputy

ENVIRONMENTAL ACTION COUNCIL
of BRAZOS COUNTY

College Station TX 77840

P.O. Box 785

February 13, 1976

District Engineer
Corps of Engineers US Army
P.O. Box 17300
Forth Worth, Texas 76102

Dear Sir:

The Environmental Action Council of Brazos County was informed by your office of an application under section 404 by the Brazos River Authority for the construction of the so-called Limestone dam and reservoir on the Navasota River.

Although this impoundment may have some effects on the Navasota River in our area, we felt the issue was not close to our main interests. Meanwhile, it has come to our attention that the U.S. Fish and Wildlife Service - in concordance with the Texas Parks and Wildlife Department - has recommended to you that the permit be denied, unless an adequate mitigation area be dedicated, the lake be filled in stages, and be designed for gradual, low-volume release of flood waters.

The first two requirements seem entirely reasonable to us and in accord with letter and spirit of the present law. Thus, we strongly endorse the stand of the U.S. Fish and Wildlife Service and urge that you, in issuing a permit, accomodate their first two recommendations. We do not believe that the third recommendation is sound, in that it appears preferable to us to operate the lake at a nearly constant level, letting occasional flood waters spill over as they may, as they do now in the absence of a reservoir. However, this point is one of operation and not of construction.

We are told by some that this is a private enterprise on private land. However, we consider that both wildlife and major streams are in the public domain. Also, that the construction proceeds with tax exempt bonds and through a public organization, the BRA.

We believe, therefore, that there is every reason that the permit should reflect current, public laws and the expressed wishes of concerned citizens. We will appreciate your attention to this matter and the receipt of additional pertinent information.

Sincerely,

Cornelius van Bavel, Chairman
Water Resources Committee, EAC of Brazos County

CC: Susan Mellor, President

TEXAS COMMITTEE ON NATURAL RESOURCES
4144 COCHRAN CHAPEL ROAD
DALLAS, TEXAS 75209
(214) 352-8370
February 28, 1976

District Engineer
U.S.Army Corps of Engineers
P.O. Box 17300
Fort Worth, Texas 76102

Re: Limestone Reservoir, Navasota River

Dear Sirs:

We understand that the U.S. Fish and Wildlife Service recommends acquiring 15,100 acres in mitigation, staging the filling by increments, and releasing in low volumes.

We warmly endorse their proposals, particularly that adequate mitigation be included in the construction plan.

Sincerely,

Edward C. Fritz

ECF:edf

cc: Cornelius Van Bavel

Rt. 3 Box 95
Hueytown, Ala. 76642.
29 Dec. 1975

Re BRA permit for the construction of Lake Limestone

Sir:

In making your decision on this matter, we hope you will consider the following fact:
There is no need for water, now or in the foreseeable future, that could not be supplied by P & S's two Lakes on Duck Creek and Steele's Creek, and by Lake Millican and Nanasota #2.

Thank you,
Mr. & Mrs. D'M Henderson

P.S. Will you please let us know when a decision is made on this permit? The BRA is in this vicinity trying to purchase land for the lake. We do not want to give up our land until we know that it will be built.

Thank you,
D'M H.

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AD-A097 021 ARMY ENGINEER DISTRICT FORT WORTH TEX F/G 13/2
STERLING C. ROBERTSON DAM AND LIMESTONE LAKE ON THE NAVASOTA RI--ETC(U)
APR 76

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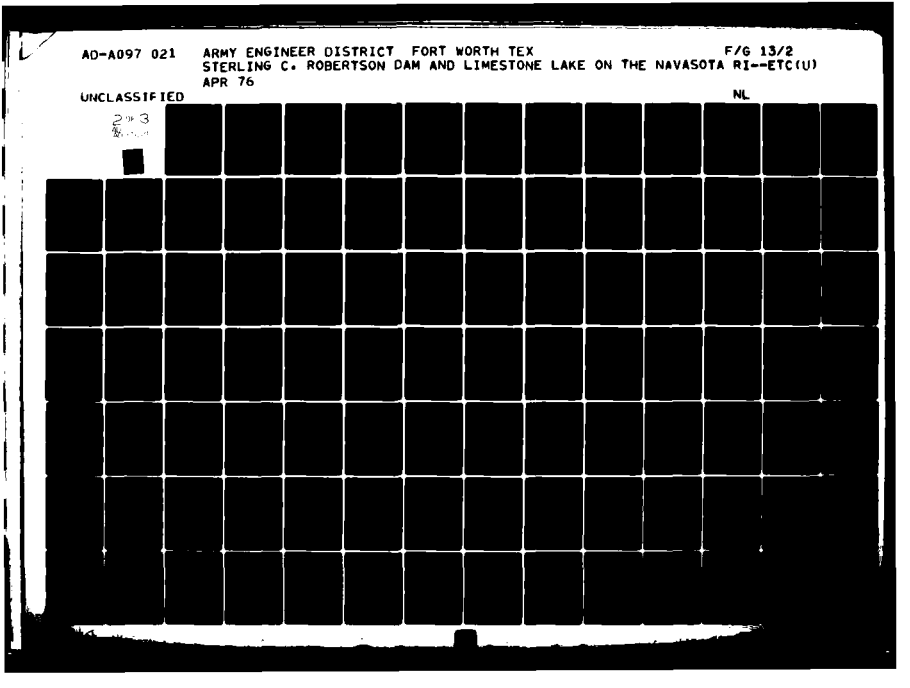
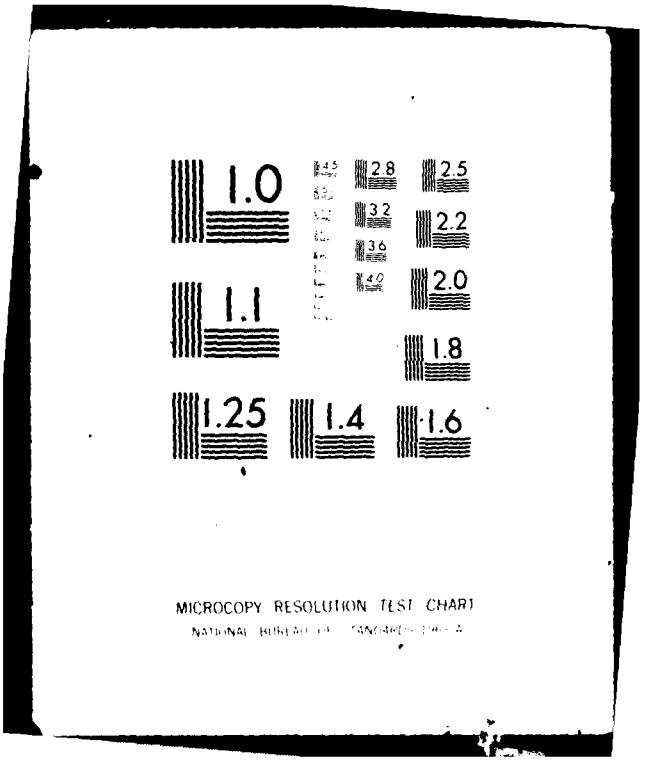
2 OF 3

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MICROCOPY RESOLUTION TEST CHART

APPENDIX

A-1. Project Description.

a. Location. The damsite for the Sterling C. Robertson Dam is on the Navasota River at river mile 124.5. This site is about 22 miles northeast of Franklin, Texas, and about 6 miles northwest of Marquez, Texas, and would extend across the Robertson-Leon County line. The lake created by the dam would lie partially in Robertson and Leon Counties but mostly in Limestone County.

b. Purpose. The purpose of the project is to supply water for municipal, industrial and irrigation use in the local area and in areas downstream. There will be an immediate need for at least 25,000 acre feet of water per annum for makeup water for the cooling ponds of two power plants planned for immediate construction on Duck and Steele Creeks (SwRI, 1975) to utilize lignite deposits in the area as a source of energy.

c. Total Drainage Area. The total drainage area upstream from the Sterling C. Robertson damsite is 674 square miles.

d. Estimated Annual Runoff at Dam Site.

	Acre-feet	Inches
Maximum (1957)	512,562	14.26
Minimum (1963)	4,861	.14
Average (30 years)	201,450	5.60

e. Spillway Design Flood.

Duration of storm	48 hours
Total depth of rainfall	17.31 inches
Initial rainfall loss	1.00 inch
Average infiltration rate	0.05 inch/hour
Total depth of rainfall excess	14.61 inches
Total depth to full reservoir	14.70 inches
Total volume of inflow to full reservoir	528,380 acre-feet
Peak inflow to full reservoir	193,100 cfs

Maximum outflow	
Service spillway	135,000 cfs
Emergency spillway	0 cfs
f. Test Flood.	
Duration of storm	48 hours
Total depth of rainfall	32.44 inches
Initial rainfall loss	1.00 inch
Average infiltration rate	0.05 inch/hour
Total depth to full reservoir	29.54 inches
Total volume of inflow to full reservoir	1,061,820 acre-feet
Peak inflow to full reservoir	368,600 cfs
Maximum outflow	
Service spillway	182,740 cfs
Emergency spillway	114,160 cfs
g. Service Spillway.	
Length at crest (net)	200 feet
Crest elevation (ft. msl)	337.0
Type	Controlled Ogee
Control	Five-40'x28' Tainter Gates
Top of gates (elevation, ft. msl)	365.0
h. Emergency Spillway.	
Type	Unpaved Broadcrested
Length	3,000 feet
Control elevation (ft. msl)	370.0

i. Low-flow Outlet.

Purpose	Diversion during construction, reservoir regulation, and releases to pass through low flow as necessary and to supply water downstream.
Size	2-4 ft x 8 ft
Location	One each in each interior pier of the service spillway
Control elevation (ft. msl)	322.0
Capacity	2,420 cfs for both outlets with water surface at elevation 363.0

j. Water Supply Outlets.

Purpose	Water supply releases
Size	2 - 36-inch diameter pipes w/three selective withdrawal inlets
Location	Right end pier
Control Elevations	Centerline of 36-inch diameter pipes at elevation 322.5. Inverts of selective withdrawal inlets at elevation 352.0, 339.0, and 325.5
Capacity (w/w.s. elev.337.0)	160 cfs w/one pipe discharging 295 cfs w/both pipes discharging

k. Bypass Outlet.

Purpose	Water supply releases and streamflow maintenance
Size	10-inch diameter pipe w/three selective withdrawal inlets
Location	Left end pier
Control Elevations	Centerline of 10-inch diameter pipe elevation 323.0. Inverts of selective withdrawal inlets at elevation 352.0, 339.0, and 325.5
Capacity (w/w.s. elev. 337.0)	10.9 cfs

1. Reservoir.

Feature	Elevation (ft. msl)	Surface Area* (acres)	Capacity* (acre-ft.)
Top of Dam	380.0	26,551	557,878
Max. W.S. Test Flood	376.0	23,200	458,603
Emerg. Spillway Crest	369.6	18,709	333,048
Max. W.S. Design Flood	369.6	18,505	325,670
Normal Pool	363.0	14,200	217,494
Service Spwy. Crest	337.0	2,840	20,616
Streambed	315.0	0	0

* Area-capacity data reflects initial reservoir conditions.

A-2. Project Structures.

a. General. The Upper Navasota Reservoir will require the following major structures at the dam site: (1) earthen dam; (2) a five-gated concrete service spillway; and (3) an uncontrolled emergency spillway cut through the abutment. Also associated with the project are relocations of state and county roadways requiring alteration or adjustment; as well as utilities such as pipelines, transmission lines, and telephone lines which must be relocated. Office and maintenance facilities will also be constructed at the reservoir site.

b. Earthen Dam. The earthen dam will consist of the main embankment, which will extend from the right abutment to the right end of the service spillway, and from the left end of the service spillway to the emergency spillway and the left abutment. The main embankment will have a length of about 8,400 feet. The embankment will have a crest elevation of 380.0, and a crown width of 20 feet. The upstream face of the embankment will have a slope of 1 on 3 above elevation 338.0 and a slope of 1 on 4 below elevation 338.0. The downstream face will have a slope of 1 on 3. The maximum height of the embankment at the river crossing will be about 72 feet. A service road will be provided on the top of the embankment section of the dam. The service road will consist of a 6-inch gravel base course surface. The upstream slope of the embankment will be protected above elevation 338.0 by a layer of dumped 24-inch riprap on a 9-inch filter blanket or 24-inch soil cement. Between elevation 330.0 and elevation 338.0, the embankment will be protected by 18-inch riprap on a 9-inch filter blanket or 18-inch soil cement. The

downstream slopes will be sprigged and seeded with grass. A one hundred foot wide berm will also be placed along the downstream slope of the embankment below elevation 338.0. The top of the berm will have a top slope of approximately one percent to provide free drainage and will be sprigged and seeded to prevent erosion. A plan of the embankment is shown on plate A-1. Typical embankment sections are shown on plate A-2 and a profile along the centerline of the dam is shown on plate A-3.

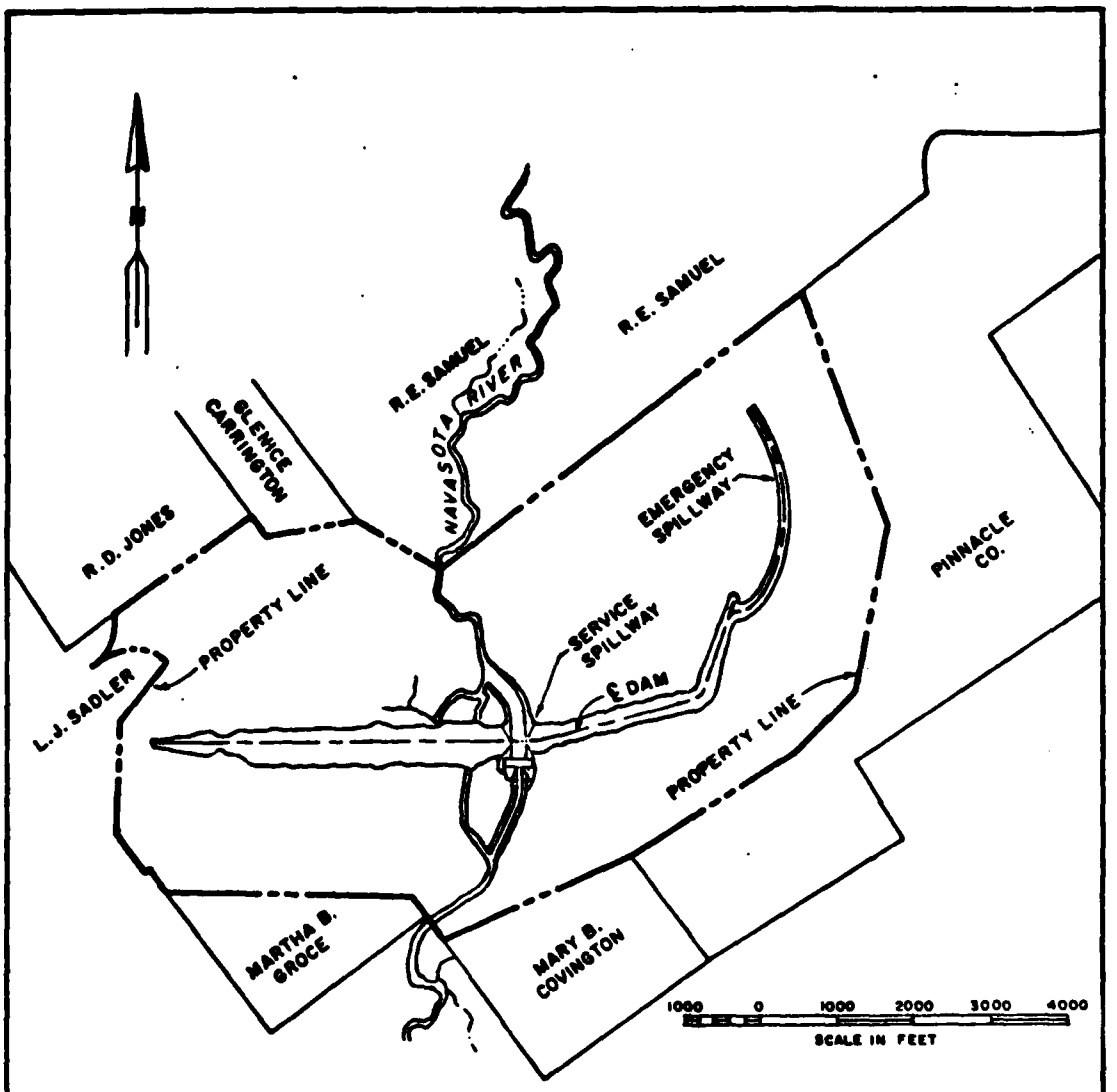
c. Service Spillway. The service spillway will be located in the valley near the river and the centerline of the service spillway will be at Station 59+00 of the dam axis. The spillway will consist of an approach channel, an ogee weir controlled by five 40' x 28' tainter gates, a chute and stilling basin, two 4-foot by 8-foot low-flow outlets, two water supply outlets, a bypass outlet, and a discharge channel. Plate A-2 shows a section through the service spillway.

The approach channel will have a bottom width of 214.5 feet, 1 on 3-side slopes and a length of about 700 feet. The approach channel will have a bottom elevation of 325.0 at the weir and will be paved with concrete for a distance of 76 feet from the weir. The paved portion of the approach channel will be 256.5 feet wide. The side slopes of the channel will be riprapped behind the approach walls.

In addition to the approach channel, a fifteen foot wide pilot channel to the low flow outlets will be placed in the center of the approach facilities. The pilot channel will have a bottom width of fifteen feet, 1 on 3-side slopes and a length of approximately 750 feet. At the juncture of the approach channel and the service spillway, the pilot channel will transition from a fifteen foot bottom width channel to a fifty-seven foot bottom width channel with 1 on 1.5 side slopes.

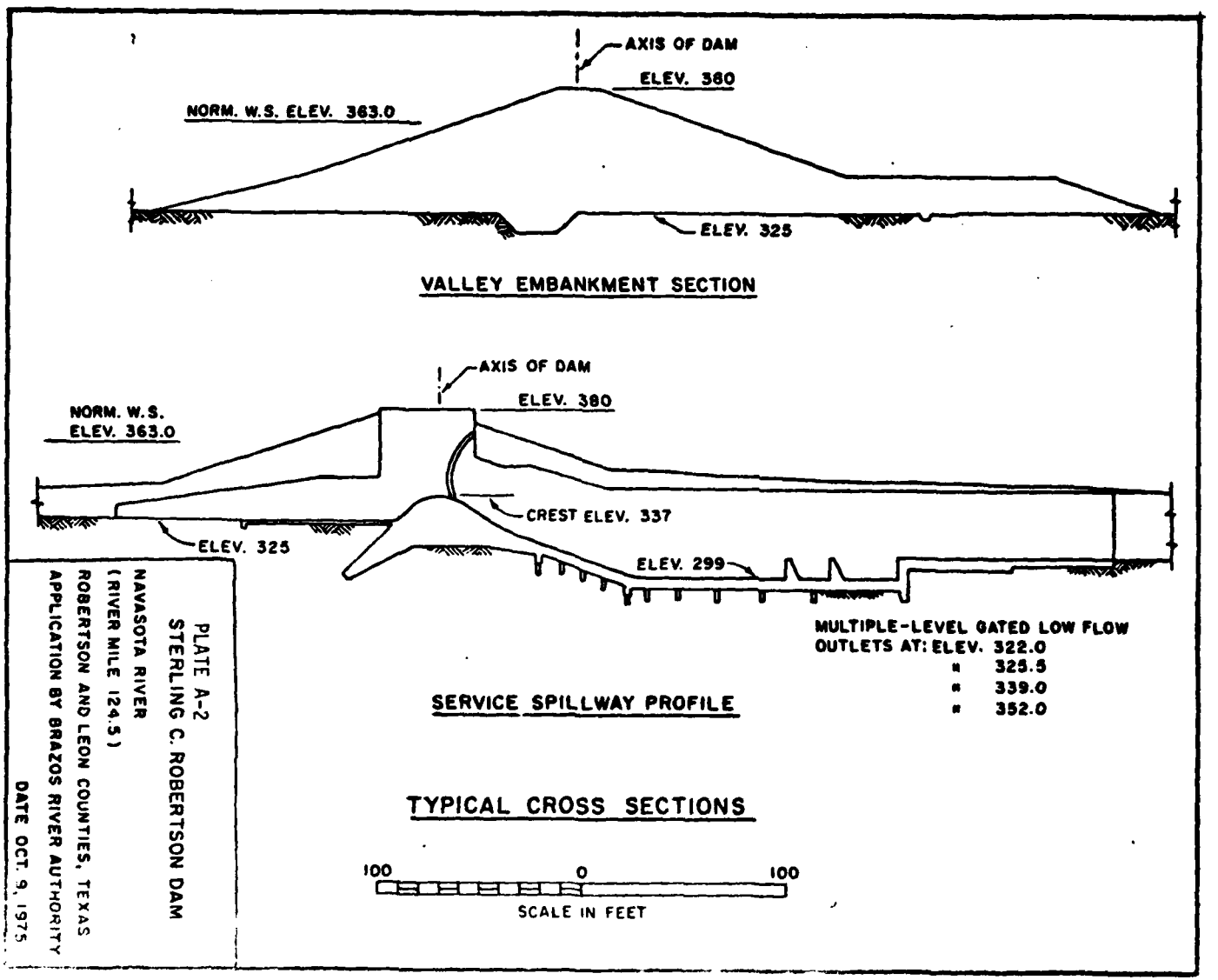
The weir will consist of a concrete, gravity, ogee-type section with a net length of 200 feet. The weir will be surmounted by five 40 feet by 28 feet tainter gates and separated by four 8-foot wide piers, flanked on each end by a 70 foot long concrete non-overflow section. The crest of the weir will be at elevation 337.0 and the weir will discharge 135,000 cfs with the reservoir level at the maximum design water surface elevation 369.6. The spillway structure will extend approximately 230 feet downstream from the crest of the weir to the downstream edge of the end sill. A 40-foot radius curve will connect the spillway chute to the horizontal apron at elevation 299.0. The chute and apron will be 232 feet wide and two rows of 11 foot high baffle blocks and an 11 foot high end sill will be provided. The top of the training walls will be at elevation 342.5 which is 5.0 feet above the maximum design tailwater elevation.

Spillway discharges will be conveyed to the river by a discharge channel which will be excavated. The discharge channel will be level with the end sill of the stilling basin for a distance of 100 feet from the end



PROPERTY OWNERSHIP MAP

PLATE A-1
STERLING C. ROBERTSON DAM
NAVASOTA RIVER
(RIVER MILE 124.5)
ROBERTSON AND LEON COUNTIES, TEXAS
APPLICATION BY BRAZOS RIVER AUTHORITY
DATE OCT. 9, 1975


AXIS OF DAM
ELEV. 380
NORM. W.S. ELEV. 363.0
ELEV. 325
VALLEY EMBANKMENT SECTION
AXIS OF DAM
ELEV. 380
NORM. W.S.
ELEV. 363.0
CREST ELEV. 337
ELEV. 325
ELEV. 299
MULTIPLE-LEVEL GATED LOW FLOW
OUTLETS AT: ELEV. 322.0
" 325.5
" 339.0
" 352.0
SERVICE SPILLWAY PROFILE
TYPICAL CROSS SECTIONS
100
0
100
SCALE IN FEET
PLATE A-2
STERLING C. ROBERTSON DAM
NAVASOTA RIVER
(RIVER MILE 124.5)
ROBERTSON AND LEON COUNTIES, TEXAS
APPLICATION BY BRAZOS RIVER AUTHORITY
DATE OCT. 9, 1975

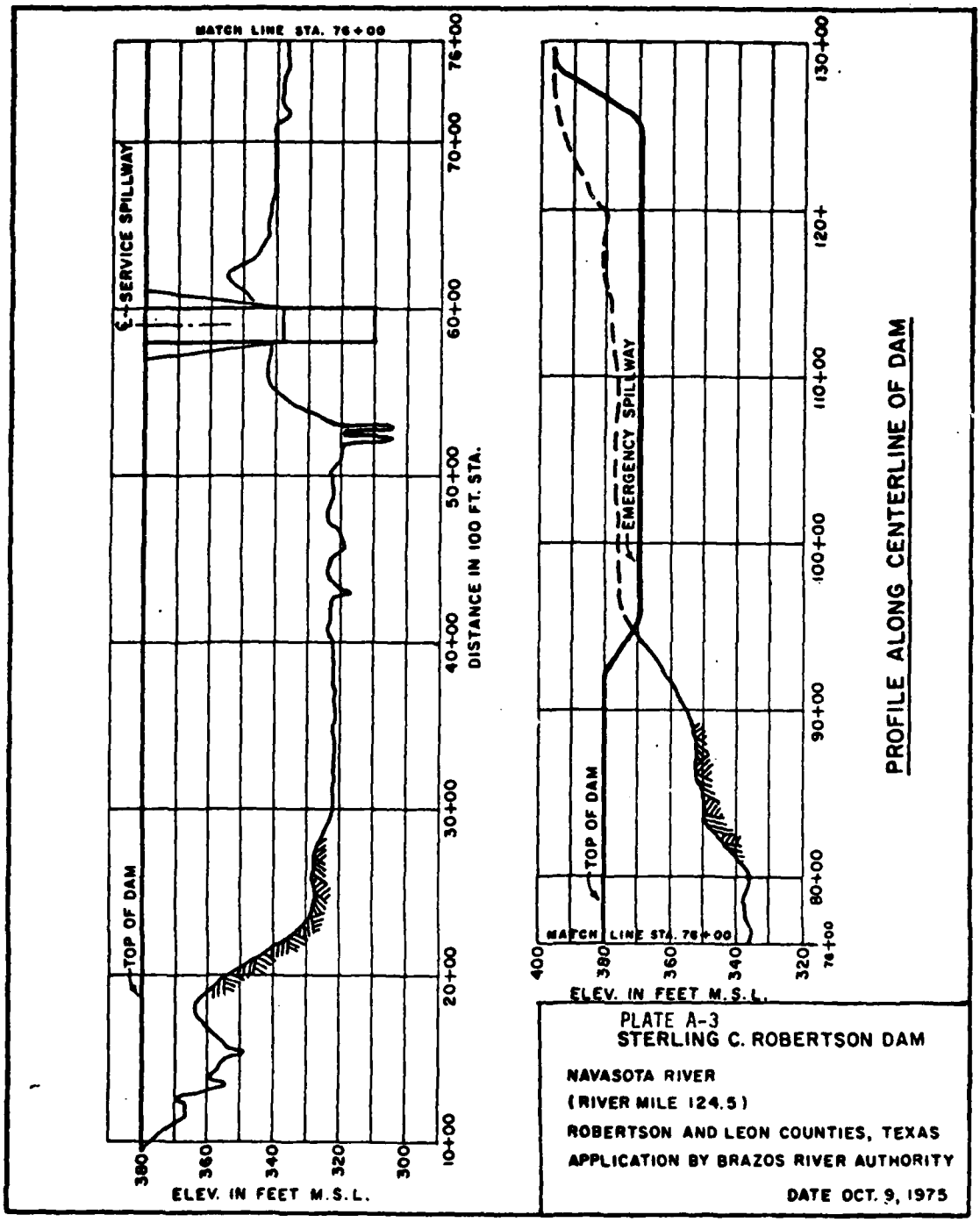


PLATE A-3
STERLING C. ROBERTSON DAM

NAVASOTA RIVER
(RIVER MILE 124.5)
ROBERTSON AND LEON COUNTIES, TEXAS
APPLICATION BY BRAZOS RIVER AUTHORITY

DATE OCT. 9, 1975

sill and will have a width of 232 feet and 1 on 3 side slopes. The channel will then slope upward to elevation 325.0 on a 1 on 10 slope with a diverging bottom width, so that at a point 200 feet from the end sill the channel bottom will be 322 feet wide. The 350 foot wide bottom width channel with 1 on 3 slopes will be excavated on a level grade for about 120 feet, where the bottom grade will intersect with the natural ground. A pilot channel will be provided in the center of the discharge channel and will extend from a point 100 feet downstream of the end sill of the stilling basin for a distance of about 1100 feet, where it will join with the main channel of the Navasota River. The pilot channel will have a bottom width of 40 feet, and 1 on 3 side lopes. Riprap will be provided for a distance of 100 feet downstream from the end sill.

The two interior piers of the weir will each contain a four foot wide by eight foot high sluice with invert elevation 322.0 at the entrance and discharge end. The sluice will be controlled by a motor operated gate with provision for hand operation in the event of failure of the motorized hoist equipment. Emergency bulkheads will be provided.

d. Emergency Spillway. The emergency spillway, which will be located at the left end of the dam, will be a country type and will consist of an approach channel, a broad-crested weir, and an outlet channel. The weir crest will have a length of 3,000 feet and a width of 20 feet. It is proposed to use the weir crest as a roadway for a service road. The approach channel will be excavated for the entire width of the spillway and will slope from the edge of the road toward the reservoir on a 0.5 percent slope. Low spots in the approach channel will be filled with waste material from the spillway excavation. The outlet channel will slope from the edge of the road on a one-percent slope.

A-3. Vegetative Clearing. Certain clearing and grubbing activities will be required in connection with the construction of the Sterling C. Robertson Dam and Lake Limestone both within and above the 363 foot msl contour.

Clearing consists of removing to ground level all trees and stumps, down timber, brush, fences, windfalls, logs, weeds, shrubs, and debris of all kinds.

Grubbing consists of the removal and disposal of all stumps and roots larger than one inch in diameter to a specified depth, and matted roots from the designated grubbing areas. In foundation areas, stumps, roots, logs or other timber more than one inch in diameter, matted roots, and other vegetative matter and debris not suitable for foundation purposes will be excavated and removed to a depth not less than 18 inches below the final foundation ground elevation.

Clearing and grubbing would be required for:

The areas to be occupied by embankments and berms and strips 10 feet wide beyond and contiguous to the toes;

Strips 10 feet wide and contiguous to the backslope on the unexcavated side of cuts for ditches, channels, roadbeds, etc.;

The areas to be used for stockpiles; and

The administration area rough grading and 10 feet beyond and contiguous thereto.

"Clearing only" would be required for:

The area to be covered with an upstream impervious blanket and 10 feet beyond and contiguous thereto;

The areas to be occupied by waste disposal;

The areas of borrow excavation;

The areas to be occupied by the service spillway and appurtenances, the emergency spillway and strips 10 feet wide and contiguous thereto; and

The areas to be excavated for ditches, channels, and roadbeds.

Within the conservation pool (below 363 feet msl) approximately 3000 acres will be cleared. The entire lake area up to elevation 363 feet msl will be cleared in the main body of the lake for a distance of approximately 1.2 miles upstream from the dam. For an additional 1.5 miles of the main body of the lake and in the tributaries for the first 2.7 miles upstream from the dam, clearing will be done up to elevation 345 feet msl. For approximately the next 7 miles upstream in the main body of the lake, a strip 2000 feet wide and approximately centered on the main channel of the Navasota River will be cleared. For an additional 2.2 miles up the center of the main body of the lake and for 3 miles up the center of both Lambs Creek and Big Creek, a strip 500 feet in width will be cleared. Clearing will be extended to the 363 foot msl contour in front of and adjacent to all public access areas, the locations of which are still to be decided.

The cleared and grubbed materials will be disposed of by burning or by other satisfactory method, such as burying in waste disposal areas provided that a minimum earth coverage of 18 inches below normal ground level plus a mound approximately six inches above normal ground level is maintained. No disposal will be allowed in or along streams. No fires will be allowed unattended and the advice and consent of the Texas Air Control Board will be required in all burnings.

Timber within the cleared areas will become the property of the contractor doing that clearing and must be disposed of as described above or by some acceptable manner.

Trees, brush, and fences outside the above described limits but within the immediate vicinity of the work may be removed by the contractor when they are not designated in the field for preservation and are in such a location as to interfere with construction activities.

A-4. Land Acquisition. The following criteria and guidelines have been adopted by the Brazos River Authority for determining the nature and extent of land and landrights needed for the Sterling C. Robertson Dam and Lake Limestone project:

> Land required for construction of the dam and appurtenant structures will be acquired in fee, except for oil and gas rights, provided that no operations for recovery of oil and gas may be conducted on the surface of the land to be thus acquired and any other operations for recovery of such oil and gas conducted on the surface of other lands shall not enter or be conducted under the surface of the lands at a depth of less than 2,000 feet beneath the surface thereof. The extent of land to be acquired will take into consideration requirements for excluding the public from the dam and from areas immediately downstream for safety reasons.
>
> Land in the lake area will be acquired in fee up to elevation 363 feet, with the landowner retaining mineral rights but with recovery operations being limited as required to accommodate the lake. If the landowner desires to retain ownership of the land below elevation 363 feet, the Authority may acquire an easement rather than fee title, provided the easement gives the Authority all of the rights needed to operate and maintain the project and provided agreement can be reached on a fair and reasonable price to pay for the easement.
>
> Landrights acquired above elevation 363 feet will be limited to easements (or releases from damages) except for areas to be acquired for public access to the lake, which will be acquired in fee (less mineral rights). Easements will be acquired up to a minimum elevation of 370 feet. By acquiring an easement over land up to at least elevation 370 feet, the Authority will be assured of having an easement over all the land around the reservoir above elevation 363 feet which is not subject to flooding from flows of the Navasota River under natural conditions but which will be (or could be under the most extreme conceivable conditions) subject to flooding after the reservoir is in operation.

In areas around the upstream portion of the reservoir, in which areas land is already subject to flooding under natural conditions and will be subject to more frequent flooding after the project goes into operation, the Authority will obtain easements up to elevations encompassing at least the 100-year flood after 50 years of siltation.

Within the easement areas described in the above paragraph, there will be areas in which the frequency of flooding will be so great as to make it inadvisable to permit structures other than roads, fences and similar structures to be built and maintained. These will be areas in which the frequency of flooding is expected to be greater than once every 10 years. The upper limits of these areas will be delineated by a contour at an elevation above that reached by the 10-year flood. Where the elevation of the 10-year flood is below elevation 366 feet, the 366-foot contour will be used to delineate the upper limits of these areas. The easements obtained in such areas (designated "restricted building areas") will contain provisions prohibiting construction of facilities other than fences, roads and similar structures; boat docks, boat houses, boat launching facilities and similar structures may be permitted under a policy to be established and administered by the Authority.

In addition, there will be areas around the lakeshore where wave action and/or variations in water surface elevation may cause sluffing or erosion of the land. If the effects of such sluffing or erosion are expected to extend beyond the limits of the areas described in the above paragraph will be delineated by lines established a sufficient horizontal distance back from the 363-foot contour to encompass the areas which may be subject to such sluffing or erosion.

The above criteria and guidelines were adopted by the Board of Directors of the Brazos River Authority on June 19, 1975.

A-5. Purpose of the Project. The primary purpose of the project is to develop the water resources of the upper Navasota River watershed in order to provide dependable water supplies to meet municipal, industrial and agricultural water needs in the local area and in areas downstream in the Brazos Basin and adjoinging coastal areas. The most urgent water need at present is the need for at least 25,000 acre-feet of water per year for industrial cooling purposes for two planned power plants in the vicinity of the Limestone Lake site. This water will be required as makeup water for the cooling ponds of the two power plants. Using locally available but previously unutilized

lignite coal as fuel, these power plants will produce electric energy for a wide area of central and north Texas. This action is expected to help alleviate possible future energy shortages.

While there are no immediate local demands for municipal water supplies from Lake Limestone, such needs may develop as the present limited supplies are used up. There will also probably be local needs for additional industrial water for use in the further generation of electric energy utilizing area lignite deposits.

In addition to meeting present and future local needs, the project will be operated as an element of the Brazos River Authority's basin-wide system of water supply lakes and will be used to help meet municipal, industrial and agricultural water needs in other areas of the Brazos Basin and in the adjoining coastal areas.

A recent study by the Brazos River Authority indicates that the long-range water supply capabilities of the Authority's basin-wide system of water supply reservoirs (including conservation storage space in Federal reservoirs as well as the reservoirs owned and operated by the Authority) are essentially committed to meeting present and projected water needs. The approximately 50,000 acre-feet of dependable long-range water supply yield remaining uncommitted is earmarked by the Authority for meeting future needs which may develop in the vicinities of individual reservoirs in the system and for such contingency purposes as possible in-transit losses in delivery of water released from reservoir storages for use in areas downstream. Future needs in the lower Brazos Basin (including the Navasota River watershed) and in the adjoining coastal areas must be met from reservoirs now under construction or planned for future construction. The proposed Lake Limestone will provide the only lake-oriented public recreation in the local area. All the other reservoirs planned for development and incorporation into the Brazos River Authority's basin-wide system of water supply reservoirs are scheduled for completion much later than Lake Limestone. Therefore, Lake Limestone is urgently needed to help assure that adequate water supplies will be available to meet the projected needs of industry, agriculture, and municipalities (BRA, 1974).

A-6. Project Costs. The total cost of the project, including land acquisition, engineering, relocations, clearing, administration, and financing, has been estimated by the Brazos River Authority to be $50 million.

No state or federal tax monies or funding will be involved in meeting the costs of the project. The project will be financed by the Brazos River Authority through the sale of bonds to private investors. Revenue from the sale of water to the Texas Utilities

Generating Company and other future contractors for water will be used to pay off the bonds and operate and maintain Limestone Lake.

Construction of the project was initiated July 22, 1975, and contract for construction of the embankment and spillway portion of the project was awarded in July, 1975, to Texas Bitulithic Company in the amount of $15,678,567.

A-7. Texas Water Rights Commision Permit. The following paragraphs are specifications of Texas Water Rights Commission Permit No. 2950, granted to the Brazos River Authority on July 29, 1974:

a. IMPOUNDMENT

Permittee is authorized to construct, and before acquiring any right hereunder shall construct, a dam and reservoir on the Navasota River and impound therein not to exceed 217,494 acre-feet of water at 363 feet above mean sea level. Station 63 + 00 on the centerline of the dam is N 42° 30' W, 4000 feet from the SW corner of the Hugh L. White Survey, Abstract No. 908, Leon County, Texas, approximately 22 miles NE of Franklin, Texas.

b. USE

Permittee is aurhorized the priority right to use 70,194 acre-feet of water from the Upper Navasota Reservoir for beneficial use. The permittee may include the amount of this priority right in computing the sum of priority rights for purposes of the system operation authorized by the Commission's order of July 23, 1964, as amended.

Permittee is authorized to divert and use not to exceed 500 acre-feet of water from the Navasota River for initial construction of the dam.

c. DIVERSION

The permittee is authorized to use the bed and banks of the Navasota and Brazos Rivers for the purpose of conveying all or part of the water authorized to be appropriated under this permit to authorized points of diversion and use in the San Jacinto-Brazos Coastal Basin as authorized by Permit No. 2661.

d. TIME LIMITATIONS

Construction or installation of all works herein authorized or required shall be in accordance with plans approved by the Commission and shall be commenced within 2 years and completed 5 years from date of issuance of this permit unless extended by the Commission.

e. SYSTEM OPERATION

The permittee is authorized to include the Upper Navasota Reservoir in its system operation as authorized by the Commission's order of July 23, 1964, as amended. For purposes of the system operation authorized by the Commission's order of July 23, 1964, the permittee is authorized to divert and use from the Upper Navasota Reservoir 70,000 acre-feet of water per annum for municipal purposes, 77,500 acre-feet of water per annum for industrial purposes, and 70,000 acre-feet of water per annum for irrigation purposes, provided that all diversions from the Upper Navasota Reservoir exceeding 70,194 acre-feet in any one calendar year shall be charged against the sum of the amounts designated as priority rights in the other tributary reservoirs included in the system operation authorized by the Commission's order of July 23, 1964, as amended.

f. SPECIAL CONDITIONS

The permittee shall provide the facilities necessary (including pumps) to pass water through the dam at all times, including the period of construction and initial filling of the reservoir.

Permittee shall establish and maintain a streamflow measuring station upstream from the reservoir at a site approved by the Commission. Records of low flow at this station and at the damsite will be maintained during the period prior to the beginning impoundment of water in the reservoir and will be used, together with other pertinent data, to establish a correlation acceptable to the Commission between low flow at the upstream station and low flow at the damsite. Low flow in paragraph (c) below refers to simulated low flow at the damsite determined on the basis of this correlation.

Permittee will pass through the dam all low flow up to 6 cubic feet per second (low flow greater than 6 cubic feet per second will be passed through to serve superior downstream water rights as deemed necessary by the Commission) and will supplement low flow by making releases from reservoir storage to maintain a minimum release at the dam of 2 cubic feet per second until such time that low flow has ceased. Daily readings of the required upstream gaging station will be made whenever reservoir releases are less than 6 cubic feet per second.

The permittee shall install and maintain a continuous lake level measuring station for Upper Navasota Reservoir and maintain the following records:

Reservoir content:

Low flow releases: and

Diversions and releases indicating quantities and uses to be charged against the priority right of this reservoir, and quantities and uses (if any) to be charged against the Brazos River Authority system operation.

All records shall be compiled monthly and reported to the Commission and annually and at other times as required.

The permittee shall survey and monument an appropriate number of sediment ranges prior to impoundment of water. A set of drawings showing the location and profile of each range shall be submitted to the Commission along with a revised elevation-area-capacity table based on the surveyed ranges.

Revised elevation-area-capacity tables based on new sediment surveys conducted at not greater than 15-year intervals following the first filling of the reservoir shall be submitted to the Commission.

This permit is issued subject to all superior and senior water rights in the Brazos River Basin.

Permittee agrees to be bound by the terms, conditions and provisions contained herein and such agreement is a condiction precedent to the granting of this permit.

The issue date on the above permit specifications is given as October 1, 1974.

B-1. Existing Surface Water Quality. Table B-1 contains a summary of water quality data for the Groesbeck station of the U.S. Geological Survey for the water years 1968 through 1973.

Table B-2 contains a summary of the surface water parameter analyses performed by SwRI (1975). Table B-3 lists the locations of the sites sampled by SwRI (1975). As was pointed out in Section II, SwRI (1975) found that 11 of the 43 parameters they measured were found in concentrations which exceeded standards more than 10 percent of the time (table B-4 lists the standards that presently exist). A discussion of these 11 parameters follows:

a. Alkalinity. The U.S. EPA (1973) lists decreases in the total alkalinity of water of more than 25 percent below the natural level as unacceptable for aquatic life. Inasmuch as alkalinity provides the buffering capacity required to resist changes in pH, some alkalinity is normally desirable. The average value for the weighted means of bicarbonate at the U.S.G.S. Water Quality Sampling Station at Groesbeck for the years 1968 through 1973 is 89 mg/l. During the sampling conducted by SwRI (1975) the total alkalinity dropped below 22.5 mg/l (25 percent of 89 mg/l) in just over 6 percent of their samples, so their concern with alkalinity for the reasons given appears to be unwarranted(table B-5).

b. Boron. The U.S. EPA (1975) sets forth the proposed maximum acceptable concentration of boron in irrigation water (the most stringent standard of the water uses) as 0.75 mg/l. EPA also describes boron concentrations of greater than 4.0 mg/l in irrigation waters as "....generally unsatisfactory for most crops." All the sampling stations of SwRI (1975) showed boron concentrations in excess of the 0.75 mg/l standard. Only during prolonged dry periods did boron levels drop below the standard maximum (table B-5).

c. Chloride. The Texas Water Quality Board standard maximum of 100 mg/l of chloride in the Navasota River and tributaries was exceeded consistently in measurements made by SwRI (1975) (table B-5). When the less stringent U.S. Public Health Service Standard maximum of 250 mg/l is used, only three Navasota River sampling cites exceeded this standard at any time during the investigation.

d. Iron. The U.S. Public Health Service drinking water standard maximum of 300 µg/l for iron was exceeded in 13 samples of the SwRI (1975) investigation, all from two sampling trips (table B-5). Samples from all other trips made by SwRI were generally well below the standard maximum.

e. Mercury. The Texas Water Quality Board Order Number 20--828-05, "Discharge of Hazardous Metals to the State of Texas," is

TABLE B-1

Existing Physiochemical Water Quality in the Navasota River Near Groesbeck, Texas.

	Weighted Average for the Water Years:					
	1968	1969	1970	1971	1972	1973
Mean Discharge (cfs)	360	147	13	148	298	247
Dissolved Silica (mg/l)	8.8	8.2	5.7	8.0	---	---
Calcium (mg/l)	29	29	33	23	---	---
Magnesium (mg/l)	3.0	3.3	4.6	2.9	---	---
Sodium and Potassium (mg/l)	19	---	46	16	---	---
Bicarbonate (mg/l)	90	91	100	74	---	---
Sulfate (mg/l)	14	17	23	14	---	---
Chloride (mg/l)	26	26	62	21	25	24
Nitrate (mg/l)	1.1	0.6	1.2	0.5	---	---
Total Dissolved Solids (mg/l)	145	151	---	127	110	130
Specific Conductance (μ mhos/cm)	265	269	418	229	221	244
Temperature Range (° C.)	10 to 29	10 to 26.5	10 to 32	4.5 to 32	1.5 to 35	4.5 to 38
Hardness Ca and Mg (mg/l)	84	87	102	69	54	81

Data Source: Geological Survey. 1968-1973. Water Resources Data Data for Texas, Part 2. Water Quality Records.

Table B-2

SURFACE WATER PARAMETERS ANALYSES

Parameter	No. of Samples	High	Low	Units
Alkalinity	16	241	19	mg/ℓ
Aluminum	93	1.4	< 1.0	mg/ℓ
Ammonia	94	< 0.05	<0.05	mg/ℓ
Arsenic	110	104	< 5	µg/ℓ
Barium	94	750	<200	µg/ℓ
Beryllium	94	<50	<50	µg/ℓ
Bio. Oxy. Demand	16	5	0.52	mg/ℓ
Boron	110	4600	<100	µg/ℓ
Bromide	16	1900	<0.1	µg/ℓ
Cadmium	110	18	<0.5	µg/ℓ
Chem Oxy. Demand	16	388	11.5	mg/ℓ
Chloride	94	600	16	mg/ℓ
Chlorine	110	1.7	<0.2	mg/ℓ
Chromium	94	3.5	<0.5	µg/ℓ
Copper	110	94	1.0	µg/ℓ
Cyanide	110	150	<1	µg/ℓ
Dissolved Oxygen	119	12.5	1.2	mg/ℓ
Fecal Coliforms	120	21.000	<1	col/100 mℓ
Fluoride	40	1516	1144	µg/ℓ
Iron	110	3100	<1	µg/ℓ
Lead	110	4	<1	µg/ℓ
Magnesium	16	34	3.4	mg/ℓ
Manganese	86	10.5	<0.3	µg/ℓ
Mercury	110	190	<0.5	µg/ℓ
Nickel	86	38	<1.5	µg/ℓ
Nitrate	40	6550	<100	µg/ℓ
Nitrite	40	125	<1	µg/ℓ
Oil & Grease	109	18	<0.1	mg/ℓ
pH	120	8.8	4.5	–
Phenols	110	70	<1	µg/ℓ
Phosphate	16	45		mg/ℓ
Phosphorous	16	190	10	µg/ℓ
Selenium	94	1.90	<1	µg/ℓ
Silver	94	9.4	<0.1	µg/ℓ
Spec. Cond.	120	2.28	<0.10	mmho/cm
Sulfate	110	43	0.5	mg/ℓ
Sulfite	16	5	1	mg/ℓ
Suspended Solids	110	332	<1	mg/ℓ
Temperature	120	32	7	°C
Tot. Dissol. Solids	110	2600	15	mg/ℓ
Turbidity	112	82	1	% trans.
Vanadium	16	400	350	µg/ℓ
Zinc	108	120	1	µg/ℓ

Data source: SwRI (1975)

TABLE B-3
Locations of Sampling Sites Used
For Surface Water Quality Analyses.

Sites	Site Description
1	Upper Steele Creek, Limestone Co.
2	Mid Steele Creek, Limestone Co.
3	Lower Steele Creek, Robertson Co.
4	Upper Duck Creek, Robertson Co.
5	Lower Duck Creek, Robertson Co.
6	Walnut Creek, Robertson Cr.
7	Navasota River at Texas Highway 164, near Groesbeck, Limestone Co.
8	Navasota River at Texas Highway 79, Robertson and Leon Cos.
9	Navasota River at U.S. Highway 79, Robertson and Leon Cos.
10	Navasota River at Old San Antonio Road, Robertson and Leon Cos.
11	Navasota River at the Sassafras Branch, Limestone Co.

Data Source: SwRI (1975)

Table 6-4

MOST STRINGENT ENVIRONMENTAL STANDARDS* AND EFFLUENT GUIDELINES

Parameter	Unit	Water Quality		Effluent Guideline	
		Standard	Ref.	Daily Avg.	Ref.
Alkalinity	mg/ℓ	20.0	4	–	–
Aluminum	mg/ℓ	5.0	4	–	–
Ammonia	mg/ℓ	0.02	4	–	–
Arsenic	mg/ℓ	0.05	5, 6	0.05	8
Barium	mg/ℓ	1.0	4, 5, 6	5.0	8
Beryllium	mg/ℓ	0.1	4	-	–
Biochemical Oxygen Demand	mg/ℓ	0.5	7	–	1
Boron	mg/ℓ	1.0	3, 5	1.0	8
Bromide	mg/ℓ	–	–	–	–
Cadmium	mg/ℓ	0.01	4, 5, 6	0.02	8
Chemical Oxygen Demand	mg/ℓ	–	–	–	
Chloride	mg/ℓ	100.0	7	–	–
Chlorine	mg/ℓ	–	4	0.5 x flow	1
Chromium	mg/ℓ	0.05	4, 5, 6	0.2 x flow	1
Copper	mg/ℓ	0.05	4	1.0 x flow	1
Cyanide	mg/ℓ	0.2	4, 5, 6	–	-
Dissolved Oxygen	mg/ℓ	5.0	7	–	–
Fecal Coliforms	No's/100 ml	200.0	4, 6, 7	–	–
Fluoride	mg/ℓ	2.0	4	–	–
Iron	mg/ℓ	0.3	4, 5, 6	1.0 x flow	1
Lead	mg/ℓ	0.05	4, 5, 6	0.1	8
Magnesium	mg/ℓ	–	–	–	–
Manganese	mg/ℓ	0.05	4, 5, 6	1.0	8
Mercury	mg/ℓ	0.002	4	0.005	8
Nickel	mg/ℓ	0.2	4	1.0	8
Nitrate	mg/ℓ	10.0	4, 6	–	–
Nitrite	mg/ℓ	1.0	4	–	–
Oil and Grease	mg/ℓ	Virtually none	6	20 x flow	1
pH	–	6.5-8.3	4	6.0-9.0	1
Phenols	mg/ℓ	0.001	6	–	–
Phosphate	mg/ℓ	–	–	–	–
Phosphorous	mg/ℓ	0.1	4	5.0 x flow	1
Selenium	mg/ℓ	0.01	4, 5, 6	0.02	8
Silver	mg/ℓ	0.05	4, 5, 6	0.1	8
Sulfate	mg/ℓ	50	7	-	–
Sulfite	mg/ℓ	250.0	6	–	-
Suspended Solids	mg/ℓ	80.0	4	100 x flow	1
Temperature	°F	85.0	4	No heat discharge	1
Total Dissolved Solids	mg/ℓ	200	7	–	–
Turbidity	%Trans	90	7	-	–
Vanadium	mg/ℓ	0.1	4	–	–
Zinc	mg/ℓ	5.0	4	1.0 x flow	1

*Standards include existing or proposed limits for drinking, irrigation, livestock, aquatic life and recreational uses.

REF:

1. USEPA, "Steam Electric Power Generating Point Source Category: Effluent Guidelines and Standards," [40 CFR Part 423], Federal Register, Vol. 39, No. 196, Part III, Washington, D.C., 8 October, 1974.
2. USEPA, "Secondary Treatment Information," [40 CFR Part 133], Federal Register, Vol. 38, No. 159, 22298-22299, Washington, D.C., Friday, August 17, 1973.
3. USEPA, "Pretreatment Standards," [40 CFR Part 128], Federal Register, Vol. 38, No. 138 19236-19237, Washington, D.C., Thursday, July 19, 1973.
4. USEPA, "Proposed Criteria for Water Quality," Vols. I and II, Washington, D.C., October, 1973.
5. U.S. Department of Health, Education and Welfare, "Drinking Water Standards 1962," Public Health Service, Washington, D.C., August, 1962.
6. Federal Water Pollution Control Administration, "Water Quality Criteria," Report of the National Technical Advisory Committee, Washington, D.C., April 1968.
7. Texas Water Quality Board, "Texas Water Quality Standards," Austin, Texas October, 1973.
8. Texas Water Quality Board, "Discharge of Hazardous Metals to the Water in the State of Texas," Board Order No. 70-0828-5, Austin, Texas, August 28, 1970.

Data source: SwRI (1975)

Table B-5

SURFACE WATER QUALITY–ALKALINITY
(mg/ℓ)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	–	–	–	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–	–	–
5	–	–	–	–	–	–	–	–	–	–
6	–	–	–	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–	–	–	–
11	178	23	74	93	121	19	169	–	–	28
12	241	99	104	68	118	97	211	–	–	68

SURFACE WATER QUALITY–BORON
(μg/ℓ)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	1870	1860	1940	1910	1490	1460	2540	2800	2410	2800
2	2000	1680	1820	1700	1760	1760	1760	1680	1530	1580
3	840	960	600	830	720	720	900	790	830	1200
4	1260	1100	1200	1140	880	880	980	1100	940	950
5	420	180	320	460	320	*	140	*	*	*
6	2540	2840	1600	4220	2200	3560	2180	4600	2200	4560
7	1190	1160	1220	1440	1300	1160	1220	890	690	1090
8	3800	1780	2240	4200	3500	2980	4200	–	–	1160
9	700	600	360	260	300	*	*	–	–	*
10	200	400	250	200	200	210	200	–	–	200
11	*	*	*	*	200	400	*	–	–	1100
12	*	*	*	*	*	*	600	–	–	200

*Below detection limit of 100 μg/ℓ.

SURFACE WATER QUALITY–CHLORIDE
(mg/ℓ)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	73	72	54	60	61	135	142	102	80	57
2	161	85	111	53	88	140	311	254	138	117
3	156	55	133	46	130	151	600	569	265	92
4	26	18.5	16	51	31.0	48.5	18.5	26.0	21	18.5
5	57.4	72.7	61.3	42.1	53.6	95.7	95.7	57.4	38.3	28.7
6	73.6	76.9	61.8	45.0	52.5	113.9	83.5	70.2	61.4	44.5
7	84.6	117	104	48.7	62	133	217	104	99.7	77.5
8	85.3	92.2	96.8	48.4	59.9	126.6	108.3	–	–	57.6
9	115	137	153	81.4	64.7	158	146	–	–	83.8
10	1425	157.5	177.5	67.5	75	167.5	217.5	–	–	87.5
11	110	130	120	70	70	37.5	167.5	–	–	47.5
12	127.5	150	132	65	70	122.5	187.5	–	–	77.5

Table B-5 (cont.)

SURFACE WATER QUALITY–IRON

(μg/ℓ)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	1900	1500	1800	3100	1200	1000	360	950	1000	1300
2	1.0	2.4	2.2	*	*	1.3	1.7	1.0	1.7	2.0
3	*	*	*	*	*	*	*	*	*	*
4	9.0	11	13	6.5	13	6.5	6.6	20	12	7.2
5	21	4.4	112	73	32	42	19	51	18	*
6	39	124	110	102	44	69	10	76	116	108
7	200	350	250	400	230	170	120	21.0	190	300
8	120	200	240	250	250	120	120	–	–	120
9	–	–	–	–	–	–	–	–	–	2.2
10	1.1	1	*	*	3.2	*	*	–	–	2.4
11	8	7.6	20	26	9.2	10	2.5	–	–	20
12	*	*	*	*	*	*	*	–	–	*

*Below detection limit of 1.0 μg/ℓ.

SURFACE WATER QUALITY–MERCURY

(μg/ℓ)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	*	*	*	*	*	*	1.3	*	*	*
2	*	*	*	1.5	*	*	0.7	*	*	*
3	1.1	*	*	*	*	*	*	*	*	*
4	*	0.50	*	*	*	*	*	*	*	*
5	*	*	*	*	*	*	*	*	*	*
6	0.65	*	*	*	*	*	*	*	*	*
7	*	*	*	*	*	*	*	*	*	*
8	*	*	*	*	*	*	*	–	–	*
9	*	*	0.8	1.0	*	*	*	–	–	*
10	55	42	190	30	70	25	110	–	–	30
11	49	21	14	5.9	6.3	2.1	5.7	–	–	7.1
12	0.73	0.56	0.5	*	*	*	0.67	–	–	*

*Below detection limit of 0.5 μg/ℓ.

SURFACE WATER QUALITY–OIL AND GREASE

(mg/ℓ)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	1.84	5.4	3.9	3.7	3.14	4.5	4.18	5.9	18	5.09
2	0.19	*	0.94	0.28	0.36	1.9	*	*	0.46	1.08
3	6.4	5.6	10	1.9	7.8	7.2	3.5	8.1	8.4	6.4
4	0.34	0.11	1.01	0.99	2.81	7.3	0.15	0.33	58	0.41
5	2.2	2.7	2.5	2.9	2.9	5.5	3.9	3	5.7	5.8
6	0.66	1.7	0.83	1.3	2.19	9.8	3.01	1.8	1.7	3.75
7	0.50	1.3	0.73	1.4	1.4	9.4	0.4	1.3	2.3	1.8
8	*	0.65	1.3	0.5	3	8.6	1.5	–	–	1.6
9	2.4	0.9	0.3	2.7	2.1	7.3	2.3	–	–	1.6
10	1.80	1.8	1.3	1.5	2.2	1.8	1.7	–	–	1.6
11	1.30	0.9	1.5	0.3	*	0.7	0.3	–	–	*
12	0.53	*	0.74	1.01	0.71	0.95	*	–	–	–

*Below detection limit of 0.1 mg/ℓ.

Table B-5 (cont.)

SURFACE WATER QUALITY - PHENOLS
(µg/ℓ)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	51	31	27	22	27	20	18	53	22	11
2	12	15	5	6	23	11	9	8	10	2
3	3	13	7.6	6	5.2	8	29	24	1.8	3
4	16	17	43	16	*	33	10	4.2	25	8
5	2	8.5	12	5.3	8.5	*	8.5	*	*	12
6	12	21	32	16	10	7.8	13	6.4	8.2	6.2
7	*	4	18.5	8.1	2.8	5.6	13.2	8.1	*	7
8	17	26	32	12	10	3.2	5.2	–	–	4.8
9	4	4	16	10	6	2	2	–	–	6
10	2	8	9	5	37	2	70	–	–	6
11	4.2	4	*	8	2.6	1.12	9	–	–	2
12	6	4.2	6	8	2	2	13	–	–	12.2

*Below detection limit of 1.0 µg/ℓ.

SURFACE WATER QUALITY - SUSPENDED SOLIDS
(mg/ℓ)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	76	78	70	71	74	92	82	98	90	116
2	62	97	5	23	*	53	133	126	95	61
3	66	59	22	58	33	89	70	70	72	63
4	72	94	72	71	76	90	99	39	56	28
5	24	49	41.5	38	26.5	77.5	89	51	54.5	81
6	16	60	68.5	35.5	41	33.5	13.5	51	50.5	22.5
7	28	33	35	23	24.2	12.9	31.2	31	30	35.2
8	50	115	55.8	95.5	86.5	83	71	–	–	68.8
9	43	142	142	68.5	55	89	88	–	–	119
10	168	322	280	246	246	278	250	–	–	295
11	56	114	125.6	52	70	206.4	90.2	–	–	246.5
12	12.5	27.5	55	17	14	55.5	49	–	–	76.5

*Below detection limit of 1.0 mg/ℓ.

SURFACE WATER QUALITY - TOTAL DISSOLVED SOLIDS
(mg/ℓ)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	550	445	390	275	370	500	600	410	395	275
2	2200	2300	1400	600	1200	1000	2600	2400	1400	1120
3	576	576	548	144	584	15	1452	876	368	252
4	159	141	120	224	161	196	148	122	122	126
5	480	52.5	452	318	44.5	580	529	390	365	302
6	432	391	312	213	300	482	376	304	284	216
7	483	559	546	224	323	589	614	474	450	357
8	236	137	435	220	68.3	547	496	–		302.8
9	710	638	615	135	255	585	540	–	–	345
10	745	735	780	300	360	680	680	–	–	445
11	653.5	613	548.3	300.8	427	1525	681	–		206.8
12	785	920	705	300	395	610	1330	–		455

Table B-5 (cont.)

SURFACE WATER QUALITY–TURBIDITY
(% Transmittance)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	45.5	31.5	15	42.5	62	20.5	15.5	11	19	9
2	59	22	55	59	82	30	19	17	20	26
3	–	28	36	–	–	–	12	6	10	–
4	12	5	6	4	4	5	4	8	3	10
5	54	28	14	30	37	37	46	15	13	9
6	60	27	17	35	39	32	65	17	29	15
7	64	42	54	45	43	44	52	42	43	29
8	49	*	10	26	16	16	12	2	4	1
9	54	6	5	65	35	16	7	11	9	16
10	70	2	24	–	58	–	38	10	24	–
11	78	24	3	38	48	1	52	12	8	2
12	72	12	41	32	49	8	22	19	10	3

SURFACE WATER QUALITY–VANADIUM
(μg/ℓ)

Collection	Site									
	1	2	3	4	5	6	7	8	9	10
1	–	–	–	–	–	–	–	–	–	–
2	–	–	–	–	–	–	–	–	–	–
3	–	–	–	–	–	–	–	–	–	–
4	–	–	–	–	–	–	–	–	–	–
5	–	–	–	–	–	–	–	–	–	–
6	–	–	–	–	–	–	–	–	–	–
7	–	–	–	–	–	–	–	–	–	–
8	–	–	–	–	–	–	–	–	–	–
9	–	–	–	–	–	–	–	–	–	–
10	–	–	–	–	–	–	–	–	–	–
11	<400	<400	<400	<400	<400	<400	<400	–	–	<400
12	<350	<350	<350	<350	<350	<350	<350	–	–	<350

Data source: SwRI (1975)

the most stringent standard for mercury. The majority of the samples taken by SwRI (1975) were below the minimum concentration detection limit, but 15 of the 110 samples taken did exceed the 5 µg/l standard (table B-5). All these 15 samples were collected during periods of very low flow.

f. Oil and Grease. Most samples taken by SwRI (1975) exceeded the Federal Water Pollution Control Administration's standard (found in "Surface Water Quality Criteria for Public Water Supplies"), virtually none. However, the existing State effluent standard of 10 mg/l was exceeded in only two of the 109 samples (table B-5).

g. Phenols. The standard maximum concentration of 0.001 mg/l of phenols was exceeded in more than one third of the samples collected by SwRI (1975) (table B-5). Those samples were generally collected during periods of heavy rainfall and the phenols were probably washed from oil fields in the area.

h. Suspended Solids. Suspended solids, a function of stream flow, generally exceeded the U.S. EPA (1973) proposed standard for aquatic life of not more than 80.0 mg/l during periods of heavy rainfall.

i. Total Dissolved Solids. The Texas Water Quality Board standard for total dissolved solids (200 mg/l) was found by SwRI (1975) to be exceeded at all sampling sites on one or more sampling trips and inversely related to stream flow rates.

j. Turbidity. None of the samples tested by SwRI (1975) met the minimum U.S. Public Health Service Drinking Water standard of 90 percent transmittance (table B-5).

k. Vanadium. All samples analyzed by SwRI (1975) exceeded the maximum allowable concentration proposed by the U.S. EPA (1973) for livestock purposes, 0.1 mg/l of vanadium (table B-5).

B-2. Point Source Discharges. The Brazos River Authority's Water Quality Management Plan (BRA, 1975) lists point sources in the Navasota River Basin. Five sources which lie within the drainage area of the Lake Limestone are given in table B-6 which also shows the recommended discharge permit limitations. None of these discharges are located within five miles of the Lake Limestone site, and secondary sewage treatment is expected to be adequate for discharges listed above (BRA, 1975).

B-3. Non-point Sources. No quantitative data are available on the non-point source discharges from rural or urban areas into the Navasota River. It is assumed that in-stream water quality measurements were a reflection of the watershed runoff effects.

TABLE B-6

Point Sources in the Lake Limestone Watershed

Name	Proposed NPDES Permit Q MGD	BOD mg/l	SS mg/l	Cl_2 mg/l	Fecal Coliform #/100 ml
City of Mexia	1.0	20	20	1.0	200
TDMH & MR Mexia State	0.45	20	20	1.0	200
City of Jewlett	0.1	20	20	1.0	200
City of Teaque	0.21	30	30	1.0	200
City of Groesbeck	0.28	30	30	1.0	200

MGD-------millions of gallons per day
mg/l------milligrams per liter
Q---------total volume discharged
BOD-------biochemical oxygen demand
SS--------suspended solids
Cl_2-------chlorine residual in effluent

B-4. Probable Future Water Quality Without the Project. The Brazos River Authority, the State of Texas, and the nation as a whole are committed to reaching the goals set forth in Public Law 92-500. The water in the upper Navasota River should remain of good quality in the future, regardless of watershed activities, since these activities are carefully regulated by the Texas Water Quality Board and the U.S. Environmental Protection Agency. The water quality standards which have been promulgated are expected to result in even more stringent future regulation of watershed activities.

The Brazos River Authority in its "Water Quality Management Plan for the Brazos Basin" (BRA, 1975) lists the entire Navasota River as an "effluent limitation segment." This means that the Navasota River presently meets the stream standards established by the Texas Water Quality Board for that segment. This good water quality has been generally verified by the above cited studies.

The requirements of the "Federal Water Pollution Control Act Amendments of 1972," (Public Law 92-500) and the Texas Water Code are expected to minimize any adverse effects that future activities within the Navasota River Watershed will have on water quality.

B-5. Probable Impact of the Proposed Project on Water Quality. The relatively good quality of the water in the Navasota River now and in the recent past in the area of the Sterling C. Robertson damsite and Lake Limestone has been documented by the USGS (1968-1973), Clark (1973), BRA (1975), and SwRI (1975). There is also evidence that the poorest water quality in the Navasota River is found during or immediately following heavy rainfall and runoff (Clark, 1973; Gallaher, 1974; and SwRI, 1975).

a. Adverse Effects. Some adverse impacts on the existing water quality can be expected during the construction period primarily in the form of increased turbidity and sedimentation, increased levels of dissolved solids, and the potential for accidental spills of fuels, oils, etc., associated with construction activities. These adverse effects are expected to be held to a minimum by the regulation of activities by the Texas Water Quality Board.

The Texas Water Quality Board reviewed the details of the proposed Sterling C. Robertson Dam and Lake Limestone project and stated in a letter to the Brazos River Authority on November 13, 1975:

> We believe there is reasonable assurance, subject to the qualifications and requirements following, that the activity you have proposed will be conducted in a manner that will not violate applicable water quality standards. This agency has not held a public hearing on this matter and the views of the public are not known. In making this certification we limit it to those things under the jurisdiction of this agency according to the various statutes which this agency administers.
>
> The following requirements are a part of the certification granted by this letter:
>
> > The work must be done with the minimum production of turbidity in the waters where the work is taking place.
> >
> > During construction, adequate erosion control measures will be taken in order to minimize runoff in the form of highly turbid waters into the river or adjacent waterways.

The discharge of oil, gasoline or other fuels or materials capable of causing pollution arising from your operations is prohibited. All construction materials shall be removed from the waterway and salvaged or legally disposed of upon completion of construction.

All shoreline from which vegetation is removed during construction and which will be above the normal waterline should be revegetated as necessary to prevent erosion and excessive turbidity.

Sanitary wastes are to be disposed of in some legal manner.

While the lake is filling, and for some time following, low oxygen levels and high organic concentrations can be expected in the reservoir itself as inundated vegetation is undergoing decomposition. The generally good quality of water entering the lake can be expected to minimize this adverse condition which will be gradually lessening with time.

b. Beneficial effects. The water quality downstream from Lake Limestone can be expected to show an improvement beginning with the impoundment of water. Decreases can be expected in coliform bacteria, turbidity, suspended solids and organic matter, color, silica, and biochemical oxygen demand (McKee and Wolfe, 1963). It is also recognized that removal of particulate matter will result in the removal of organic pollutants such as pesticides and heavy metals (LeGrand, 1966).

Another downstream water quality benefit that can be anticipated following completion of the project is the low-flow augmentation which is a requirement of the Texas Water Rights Commission Permit No. 2950 for the Sterling C. Robertson Dam and Lake Limestone project. Under present conditions, there are often periods when there is no flow in the Navasota River throughout a large portion of its length. Details of the low-flow release requirements can be found in appendix A-7.

c. Conclusions. While there will be temporary adverse impacts on water quality during construction, the long-term effects from a water quality standpoint will be a moderate improvement to the quality of the water in the Navasota River as a result of the project.

B-6. Existing Ground Water Quality. The most pertinent data available on the quality of ground water in the area of the proposed Limestone Lake are those from the field study conducted by SwRI (1975). Ground water parameters analyzed are shown in table B-7. They selected

Table B-7

GROUND WATER PARAMETER ANALYSES

Parameter	No. of Samples	High	Low	Drinking Water Standards	Units
Alkalinity	7	195	38	–	mg/ℓ
Aluminum	42	<1	<1	–	mg/ℓ
Ammonia	42	<0.05	<0.05	–	mg/ℓ
Arsenic	48	32	<5	50	µg/ℓ
Barium	42	900	<200	1,000	µg/ℓ
Beryllium	42	<50	<50	–	µg/ℓ
Bio. Oxy. Demand	7	0.98	<0.01	–	mg/ℓ
Boron	48	5000	<100	1,000	µg/ℓ
Bromide	7	1000	<0.1	–	µg/ℓ
Cadmium	49	7.8	<0.5	10	µg/ℓ
Chem. Oxy. Demand	7	52	4	–	mg/ℓ
Chloride	49	466	6.9	250	mg/ℓ
Chlorine	31	1.7	<0.2	–	mg/ℓ
Chromium	42	2.2	<0.5	50	µg/ℓ
Copper	49	350	<0.3	1,000	µg/ℓ
Cyanide	49	90	<1	200	µg/ℓ
Dissolved Oxygen	50	8.4	<0.05	–	mg/ℓ
Fecal Coliforms	49	2058	<1	2,000	col/100 mℓ
Fluoride	16	1867	200	1,400	µg/ℓ
Iron	45	5500	<1	300	µg/ℓ
Lead	49	6.4	<1	50	µg/ℓ
Magnesium	7	20	2.8	–	mg/ℓ
Manganese	42	3.6	<0.3	50	mg/ℓ
Mercury	49	26	<0.5	–	µg/ℓ
Nickel	42	49	<0.5	–	µg/ℓ
Nitrate	16	5000	<100	10,000	µg/ℓ
Nitrite	16	64.6	<1	1,000	µg/ℓ
Oil and Grease	49	5.3	<0.1	–	mg/ℓ
pH	49	7.6	4	–	–
Phenols	49	51	<1	10	mg/ℓ
Phosphate	7	25	5	–	mg/ℓ
Phosphorous	7	280	1	–	µg/ℓ
Selenium	42	1.25	<1	10	µg/ℓ
Silver	42	2.1	<0.1	50	µg/ℓ
Sulfate	46	17	<0.5	250	mg/ℓ
Sulfite	7	3	1	–	mg/ℓ
Suspended Solids	47	245	<1	–	mg/ℓ
Temperature	49	28.62	10.70	–	°C
Tot. Dissol. Solids	49	2100	21	500	mg/ℓ
Turbidity	42	100	4	>90	% trans.
Vanadium	7	400	350	–	µg/ℓ
Zinc	48	1019	1.6	5,000	µg/ℓ

Data source: SwRI (1975)

Table B-8

GROUND WATER QUALITY–BORON
(µg/ℓ)

Collection	Site												
	Impoundment Areas				Above Lignite				Below Lignite				
	1	2	9	10	4	5	7	11	3	6	8	11*	12
1	1440	2080	2020	2320	1880	1960	–	–	2130		–	–	2060
2	–	–	–	680	776	–	1240	1360	–	1144	1260	1440	–
3	–	–	–	560	–	–	–	1240	–	–	–	–	680
4	–	1140	–	–	1080	–	1060	–	–	–	–	–	–
5	–	–	–	1600	–	–	–	1000	–	–	–	*	*
6	–	2800	–	–	3560	–	3560	–	–	–	–	–	–
7	–	–	–	960	–	–	–	1090	–	–	–	1160	1160
8	–	4300	–	–	5000	–	2400	–	–	–	–	–	–
9	–	–	–	200	–	–	–	460	–	–	–	200	*
10	–	200	–	–	220	–	1100	–	–	–	–	–	
11	–	–	–	200	–	–	–	*	–	–	–	*	*
12	–	160	–	–	100	–	–	–	–	–	–	–	–

*Below detectable limits of 100 µg/ℓ.

GROUND WATER QUALITY–IRON
(µg/ℓ)

Collection	Site												
	Impoundment Areas				Above Lignite				Below Lignite				
	1	2	9	10	4	5	7	11	3	6	8	11*	12
1	*	*	*	*	360	*	–	–	5500	–	–	–	1800
2	–	–	–	1.7	1.7	–	2.0	2.6	–	2.6	1.3	1.3	–
3	–	–	–	*	–	–	–	*	–	–	–	–	410
4	–	1.9	–	–	*	–	1.9	–	–	–	–	–	–
5	–	–	–	3.5	–	–	–	10	–	–	–	66	19
6	–	21	–	–	16	–	8.7	–	–	–	–	–	–
7	–	–	–	13.0	–	–	–	150	–	–	–	430	1200
8	–	150	–	–	100	–	100	–	–	–	–	–	–
9	–	–	–	–	–	–	–	–	–	–	–	–	–
10	1.4	–	–	–	*	–	*	–	–	–	–	–	–
11	–	–	–	1.4	–	–	–	*	–	–	–	56	21
12	–	*	–	–	*	–	*	–	–	–	–	–	–

*Below detectable limits of 1.0 µg/ℓ.

GROUND WATER QUALITY–PHENOLS
(µg/ℓ)

Collection	Site												
	Impoundment Areas				Above Lignite				Below Lignite				
	1	2	9	10	4	5	7	11	3	6	8	11*	12
1	27	27	27	16	42	13	–	–	44	–	–	–	16
2	–	–	–	27	4	–	11	7	–	2	13	16	–
3	–	–	–	20	–	–	–	24	–	–	–	–	*
4	–	4.2	–	–	51	–	*	–	–	–	–	–	–
5	–	–	–	8.5	–	–	–	2	–	–	–	*	*
6	–	13	–	–	9.2	–	7.2	–	–	–	–	–	–
7	–	–	–	4	–	–	–	2.5	–	–	–	2.5	16
8	–	*	–	–	6.0	–	3.8	–	–	–	–	–	–
9	–	–	–	*	–	–	–	9.8	–	–	–	2	10
10	–	4	–	–	2	–	*	–	–	–	–	–	–
11	–	–	–	*	–	–	–	3	–	–	–	6	6
12	–	12	–	–	6	–	11	–	–	–	–	–	–

*Below detectable limits of 1.0 µg/ℓ.

Table B-8 (cont.)

GROUND WATER QUALITY–TOTAL DISSOLVED SOLIDS
(mg/ℓ)

Collection	Site												
	Impoundment Areas				Above Lignite				Below Lignite				
	1	2	9	10	4	5	7	11	3	6	8	11*	12
1	485	1300	1050	1450	155	650	–	–	95	–	–	–	270
2	–	–	–	900	900	–	2100	900	–	700	700	400	–
3	–	–	–	316	–	–	–	292	–	–	–	–	228
4	–	886	–	–	334	–	544	–	–	–	–	–	–
5	–	–	–	408	–	–	–	382	–	–	–	234	292
6	–	227	–	–	295	–	263	–	–	–	–	–	–
7	–	–	–	374	–	–	–	409	–	–	–	183	245
8	–	47.3	–	–	21.0	–	177	–	–	–	–	–	–
9	–	–	–	370	–	–	–	650	–	–	–	200	245
10	–	280	–	–	440	–	440	–	–	–	–	–	–
11	–	–	–	383	–	–	–	567.3	–	–	–	234.8	274.5
12	–	645	–	–	385	–	830	–	–	–	–	–	–

GROUND WATER QUALITY–TURBIDITY
(% Transmittance)

Collection	Site												
	Impoundment Areas				Above Lignite				Below Lignite				
	1	2	9	10	4	5	7	11	3	6	8	11*	12
1	83	85	96	87	46	96.5	–	–	71	–	–	–	98
2	–	–	–	85	98	–	100	91	–	4	97	66	–
3	–	–	–	–	–	–	–	–	–	–	–	–	–
4	–	60	–	–	98	–	100	–	–	–	–	–	–
5	–	–	–	90	–	–	–	86	–	–	–	64	84
6	–	34	–	–	85	–	82	–	–	–	–	–	–
7	–	–	–	95	–	–	–	100	–	–	–	54	66
8	–	23	–	–	99	–	68	–	–	–	–	–	–
9	–	–	–	98	–	–	–	100	–	–	–	46	86
10	–	73	–	–	100	–	100	–	–	–	–	–	–
11	–	–	–	–	–	–	–	–	–	–	–	–	–
12	–	70	–	–	98	–	93	–	–	–	–	–	–

FECAL COLIFORM DATA

Counts in No./100 mℓ

Site	Data												
	7-24	8-24	9-22	10-23	11-14	12-13	1-8	2-6†	3-6†	4-2†	5-1†	6-1†	Log Avg
1	600*	200*	55*	1100*	60*	140*	322*	1500*	240	64	32	118	186
2	250*	200*	47	500*‡	100*	260	156	420	260	138	192*‡	96	182
3	100*	<1*	216	4000*	130*	260	96	150	290	120	1940*	124	163
4	150*	750*	615	2400	200	670	40	440	460	184	104	230	310
5	<1*	500*	665*	3200	110*	200	54	140	190*	62	960*	120	158
6	<1*	250*	250	2700	230	560	104	380	300	150	7900*‡	148	244
7	300*	700*	15*	1200*	50*	280	90	124	210	64	210	174	160
8	50*	<1*	24*	700*	180*	160*	24*	146	82	110	164	100	69
9	50*	145*	80*	1400*	100*	140*	44	102	104	74	270*	52	115
10	100*	<1*	40*	800*	150*	300	118	168*	86	178	21000*	60	140
Average	160	275	201	1800	131	297	105	357	222	114	3277	122	–

*Estimated numbers based on nonideal colony count.
†Filtering, incubation, and counts done in field
‡Alternate sites collected.

Data Source: SwRI (1975)

six wells which would be representative and measured the same parameters as were measured for surface water quality (table B-8).

Only seven of the parameters analyzed ever failed to meet the existing or proposed standards and only five failed to meet the standards in more than 10 percent of the samples taken. A discussion of these five parameters follows:

Boron. At the wells nearest the site of the proposed Limestone Lake (sites 1 and 2 in table B-8), the drinking water standard of a 1000 µg/l maximum was exceeded in five of seven samples.

Iron. The U.S. Public Health Service Drinking Water Standards maximum for iron (0.3 mg/l) was exceeded in each sample from the site of the proposed Limestone Lake (table B-8).

Phenols. The drinking water standards for phenols (10 µg/l maximum) were exceeded in two-thirds of the samples taken at sites 1 and 2 (table B-8).

Total Dissolved Solids. The drinking water standards list a maximum concentration of 500 mg/l of total dissolved solids. Nearly half the samples taken at sites 1 and 2 exceeded this maximum (table B-8).

Turbidity. None of the samples taken at sites 1 and 2 met the minimum standard of 90 percent transmittance.

a. Summary. Ground water in the area appears to meet existing and proposed drinking water standards for all but the above five parameters. Many parameters measured by SwRI (1975) do not have established standards for drinking or irrigation purposes. They will, however, serve as a baseline against which future water quality requirements and measurements may be compared.

b. Impacts on Ground Water Quality. No adverse or beneficial project impacts on ground water quality are anticipated.

B-7. Ground Water. The principal aquifers in the 3-county area are described in the Environmental Impact Assesment Report, Twin Oak and Oak Knoll Steam Electric Generating Facilities, (SwRI, 1975) as follows:

> The Trinity sands aquifer in extreme northwestern Limestone County, and the Carrizo-Wilcox sands aquifer, which covers all of Leon and Robertson counties and southeastern Limestone County, are the major ground water sources for the three-county area.

Minor aquifers are the Woodbine sands in northern Limestone County and the Queen City and Sparta sands, which cover most of Leon County and the southern half of Robertson County. There are several deep wells in the area which tap into major and minor aquifers. These wells are drilled principally to ensure sufficient water for irrigation purposes. Many wells in this area are drilled in depth to bypass shallow, iron-laden water. Irrigation has been limited in Leon and Limestone Counties, but as late as 1964 there were over 41 thousand acres being irrigated in Robertson County and over 80 percent of this was using ground water.

Limestone Reservoir will be confined to the recharge area of the Carrizo-Wilcox aquifer. The thickness of the aquifer ranges from about 1500 feet near the dam site to about 3300 feet in Southeastern Leon County. The aquifer consists of about 50 percent fine-grained, loosely cemented quartz sand. The other 50 percent of the aquifer consists of silicified wood, lignite, clay balls and clay seams in the Wilcox and principally shale in the Carrizo formation. Although the water quality in Carrizo-Wilcox wells is generally good, Limestone County wells are in the outcrop area of the aquifer and generally encounter a more mineralized water than do the artesian wells in Robertson and Leon Counties, the average specific capacity in the general area is about 10.5 gallons per minute per foot of drawdown. The average transmissibility is about 19,000 gallons per day per foot. The yields of wells vary greatly depending on the needs of the users. Municipal wells may vary from 40 to 150 gallons per minute while irrigation wells may range as high as 1,500 gpm.

The present withdrawal from the Carrizo-Wilcox aquifer is small compared to the quantity available. In 1960, withdrawals in Leon County were 281 acre-feet for municipal purposes and approximately 267 acre-feet for irrigation. Peckham (1965) estimates that about 68,000 acre feet could be developed from the Carrizo-Wilcox aquifer in Leon County. The water is very good with dissolved solids ranging from 143 to 591 parts per million. The water is suitable for most purposes with little treatment except when iron or hydrogen sulfide is encountered.

B-8. Alteration of Ground Water Hydrology. The lake is expected to provide recharge to the Wilcox aquifer. Based on hydrologic studies of the effects of Tennessee Colony dam on the Carrizo-Wilcox aquifer, the additonal hydraulic head provided by the lake at maximum pool level would cause some recovery of water levels in Carrizo-Wilcox wells downdip from the lake. Rises of up to five feet could be experienced downdip, within a five mile radius of the lake.

B-9. Effects of Lake on Ground Water Tables. The ground water level in the alluvium and terraces of the Navasota River flood plain would be raised. Under natural conditions the levels are dependent on seasonal variations in rainfall and river stage. The overall effects of the lake would be a raising and stabilizing effect on the water table in the alluvial and terrace deposits along the lakeshore and downstream from the dam. Rises in the water table would not exceed 20 feet immediately adjacent to the lake and the effect would diminish rapidly in only a short distance from the shoreline (less than one mile). The recharge effect on the alluvium below the dam would extend further downstream than the lateral effects adjacent to the lake. These effects could occur as far as three miles downstream from the dam.

C-1. Biological Elements.

a. Flora. The proposed lake is to be located in the Post Oak Savannah vegetational area (Gould, 1969) (see figure C-1). This region includes both oak-hickory or deciduous forest formation and true prairie association of the grassland formation. The topography is gently rolling to hilly with elevations between 300 and 800 feet msl. Annual precipitation is about 40 inches. Upland soils are light colored acid sandy loams or sands. Bottomland soils are darker acid sandy loams or clays (Gould, 1969).

According to SwRI (1975), a total of 210 species were identified resulting from two series of plant collections from the Navasota River Study area. In the study, two general vegetative sites were determined; i.e., the forest and prairie types. Of the 14,200 acres to be inundated by the proposed lake, 9,479 acres (or 66.7 percent) are in forest, and 4,729 (or 33.3 percent) are in prairie. Species common to the upland forest site included post oak (Quercus stellata), several grasses (Panicum sp.), winged elm (Ulmus alata), slender copperleaf (Acalypha gracilens), holly (Ilex sp.), blackjack oak (Quercus marilandica), bull briar (Smilax bona-nox), flatsedge (Cyperus sp.), and Spanish mulberry (Callicarpa americana). Common bottomland forest species included pecan (Carya illinoensis), post oak (Quercus stellata), hackberry (Celtis sp.), elm (Ulmus sp.), and holly. Species common in the prairie site included Croton sp., prairie crusae (Crusea tricocca), Bermuda grass (Cynodon dactylon), flatsedge, Panicum, sneezeweed (Helenum amarum), Drummond nailwort (Paraonychia drummondii), Paspulum, coast sandbur (Cenchrus incertus), sedge (Carex sp.), Oxalis, and vetch (Vivia sp.).

There are no known species in the project area classified as rare, endangered or threatened by extinction.

More comprehensive lists of the plant species in the Navasota Project area and River Study area are included in tables C-1, and C-2, respectively, at the end of this section.

b. Fauna.

Fish. A total of 56 species belonging to 14 families and 9 orders were taken during 136 collections at 105 localities on the Navasota River between May 1967 and July 1968. Several types of habitats were sampled, including sandy stretches, gravel and sand riffles, narrow gravel-bottom streams, and large mud-bottom reservoirs. Some of the more common species collected are found throughout most or all of Texas. However, certain species reach the limits of their recorded range in the Navasota drainage area. The stoneroller (Campostoma anomalum), apparently reaches its southeastern boundary in this watershed. The blackspot

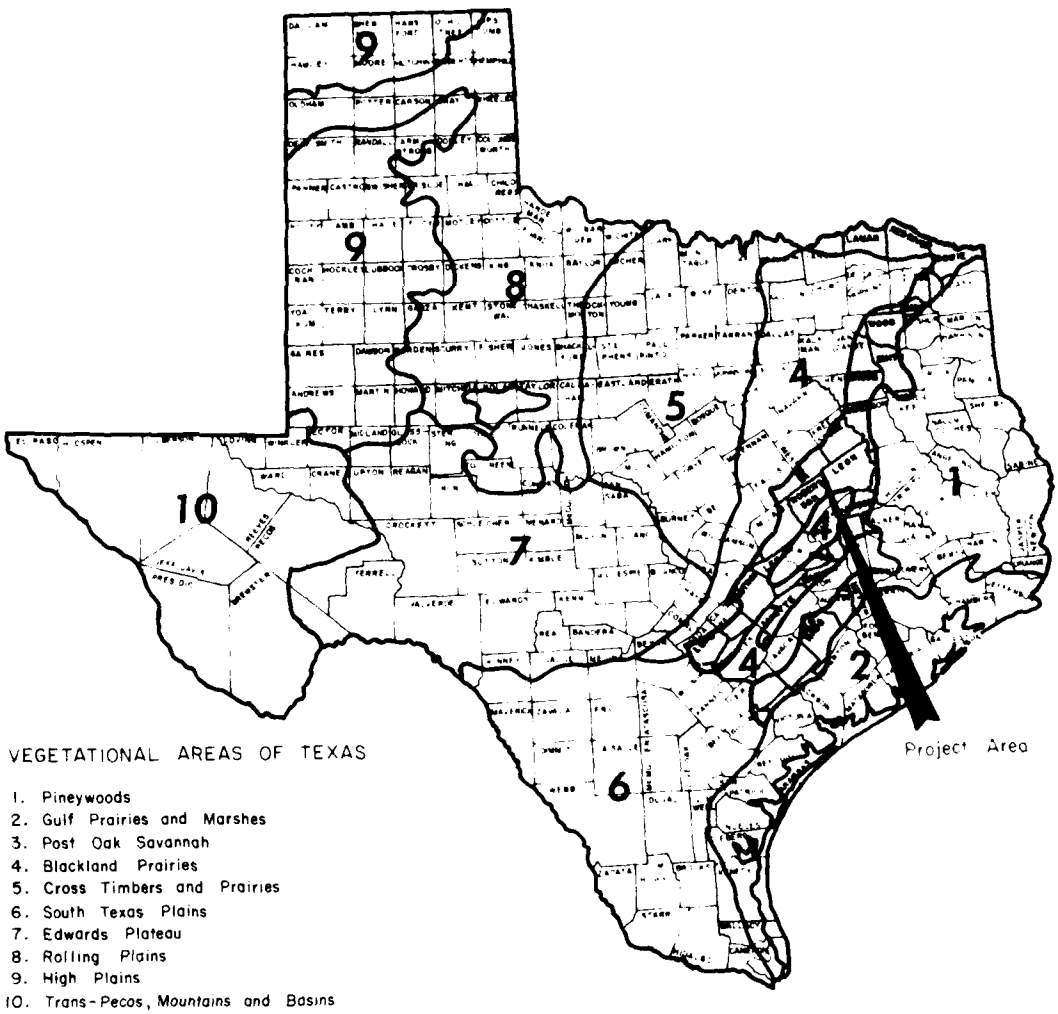


Figure C-1. The Relationship Between the Post Oak Savannah (shaded area) and the other Vegetational Areas of Texas (after Gould, 1969).

shiner (Notropis atrocaudalis) and blackspotted topminnow (Fundulus olivaceous) apparently reach their western boundary, and the western limit of the ranges of the dollar sunfish (Lepomis marginatus), bantam sunfish (L. symmetricus), and goldstripe (Etheostoma parvipinne) are at the eastern edge of the Navasota drainage area. The fauna collected is different from other parts of the Brazos River Drainage in that the species are more representative of eastern drainages; i.e., Astroriparian (Blair, 1950), rather than the rest of the Brazos (Rozenburg et al., 1972).

There are no known species considered rare, endangered, or threatened by extinction in the project area. A more comprehensive list of the fish species of the Navasota River, Texas is included in table C-3.

Birds. The diversity of birds in Texas naturally reflects the extremely varied climate, physiography, and vegetation of the State. Each region supports certain species adapted to a particular combination of weather, terrain, and flora (Oberholser et al., 1974).

From over 540 species reported in the State by Peterson (1963), field personnel sighted and identified 103 different species in the study area and 10 more were not definitely identified. Some of the more common species were: starling, turkey vulture, meadowlark, crow, cardinal, mourning dove, Brewer's blackbird, barn swallow, robin, Savannah sparrow, dickcissel, song sparrow, tufted titmouse, Carolina chickadee, Harris sparrow, common grackle, Canada goose, junco, snow goose, killdeer, scissor-tailed flycatcher, upland plover, mallard duck, vesper sparrow, lesser yellowlegs, and whiterumpted sandpiper. Also, one reported endangered species, the American peregrine falcon, was sighted in the study area (SwRI, 1975).

According to TOES (1975), species listed as rare, endangered, or threatened by extinction and having a range that is either Statewide or includes all or part of the study area are:

Species	Range in State	Habitat Preference
Swallow-tailed Kite (Elanoides forficatus)	Eastern half	Open woodlands
Bald Eagle (Haliaeetus leucocephalus)	Statewide	Lakes & larger rivers
Golden Eagle (Aquila chrysaetos)	Statewide	Mountains & hill country

Species	Range in State	Habitat Preference
Osprey (Pandion Haliaetus)	Statewide	Lakes & reservoirs
Peregrine Falcon (Falco peregrinus)	Statewide	Lakes & mountains
Prairie Falcon (F. mexicanus)	Statewide except extreme east	Open country and arid areas
Merlin (F. columbarius)	Statewide	Open country

A list of the birds sighted in the study area is included in table C-4.

Mammals. The study area is located along the north to south border that divides Blair's (1950) Texan and Austroriparian biotic provinces (figure C-2). There is an important intermixing of faunas in this transitional area. This is demonstrated by the fact that of the 49 mammals reported to occur in the Texan, 41 also occur in the Austroriparian. Within the Texan there is also an interdigitation (i.e., different ecological associations existing in the same area because of local soils related differences) of forest and grassland associations. The Austroriparian or eastern species found in the Texan are restricted more to the oak-hickory forest or flood plain forest. Similarly, the species entering the Texan from the west are largely limited to the prairies (Blair, 1950).

As a result of sightings during field trips to the area, 20 species of mammals were reported in the study area. The most frequently sighted mammals were the raccoon and armadillo. Coyote, deer, bobcat, and oppossum were also common. Due to unfavorable weather contions, very few identifications were obtained from trapping rodents, resulting in little information on these species (SwRI, 1975).

Davis (1974) reports an additional 23 species with a range in the State that includes all or a portion of the study area. These species include mainly bats, rodents, and carnivores.

There are no known species in the project area classified as rate, endangered, or threatened by extinction.

A list of the mammals reported in the study area is included as table C-5.

Figure C-2. The location and extent of the Navasota River Basin within the Biotic Provinces of Texas (Blair, 1950).

Amphibians and Reptiles. Raun and Gehlbach (1972) reported, either from the literature or by observation, 71 amphibian and reptile species in Limestone, Leon, or Robertson counties. These included four sirens, salamanders and newts, 18 frogs and toads, 11 turtles, 10 skinks and lizards, one alligator, and 27 snakes.

In field studies, SwRI (1975) sighted and identified 19 of the same species (12 frogs and toads, four skinks and lizards, and three snakes) and one additional species of lizard. The amphibians were sighted mainly during the warmer months at stream and tank sites. Very few reptiles were observed because they followed the same seasonal cyclic pattern caused by the lower temperatures in January and February.

The alligator, Alligator mississippiensis, is the only known species classified as rare or endangered known to exist in the project area.

A list of the amphibian and reptile species known or reported from the project area is included in table C-6.

Navasota River Limnology. An inventory of the aquatic and benthic organisms of the Navasota River conducted by Clark (1973) included taxonomic investigations of the blue-green algae, bacteria, protista (green algae, diatoms, and protozoans), invertebrates (flat-worms, nematodes, rotifers, roundworms, arthropods, clams and mussels, and snails) and vertebrates (bony fishes). Check lists of the reported species are included in table C-7 (aquatic organisms) and table C-8 (benthic organisms).

C-2. Impacts on Biological Elements.

Fish. Construction of the proposed Sterling C. Robertson Dam and Limestone Lake will cause some change in the local fish fauna. Riffle-dwelling species and other lotic (flowing-water) fishes will be adversely affected as the reservoir fills and streams are replaced by the lake. Suitable habitats, e.f., gravel-riffles and sandbar areas, will be inundated or destroyed by construction, The dusky darter (Percina sciera) will face probable extermination in the lake area, resulting from elimination of these riffle areas. In addition, other small fishes such as the ribbon shiner (Notropis fumeus), silverband shiner (N. shumardi)ghost shiner (N. buchanani), silvery minnow (Hybognathus nuchalis), tadpole madtom (Noturus gyrinus), Bluntnose darter (Etheostoma chlorosomum), and slough darter (E. gracile) which are found almost exclusively in lotic habitats, will be adversely affected. Species already inhabiting lentic habitats such as gizzard shad (Dorosoma cepedianum), white crappie (Pomoxis annularis), smallmouth buffalofish (Ictiobus bubalus), several species of sunfish (Lepomis sp.), largemouth

bass (Micropterus salmoides), and freshwater drum (Aplodonotus grunniens) will benefit from the reservoir. The resulting reservoir will probably develop large populations of catfish (Ictalurus sp.) and sunfish which are popular game species, as well as several non-game species of gar (Lepisosteus sp.), carp (Cyprinus sp.), and buffalofish (Rozenburg et al., 1972).

Natural River. There will be an elimination and loss of about 15 miles of riverine habitat on the Navasota River resulting from inundation. This distance represents about 10 percent of its total length or about 8.7 percent of the total distance of natural flowing river. Very little fishing presently is done in this reach.

Habitat. There will be a permanent loss of 14,200 acres of terrestrial wildlife habitat within the water supply pool, for which there is no mitigation land associated with the proposed project. An additional 1,000 acres will be lost as a result of dam and spillway construction and public use and access requirements. The proposed lake will increase available aquatic habitat for migrant waterfowl, shorebirds, and other aquatic species. Peripheral project lands containing upland forest and prairie habitats will be accessible to the public which could result in adverse impacts through misuse or abuse.

Amphibians and Reptiles. Those species now inhabiting the bottomlands would suffer the greatest impact due to displacement by inundation. Public development at the lake and private developments in proximity to the project will cause additional displacement of upland species through reduction of available habitat and physical disturbance. Some protection and restabilization of upland populations will occur in suitable habitats along the periphery of the lake because of developmental restrictions on project lands. In the downstream area, water releases will aid in stabilizing certain bottomland species.

Birds. Approximately one-fourth of the avian species in the project area will be reduced or eliminated due to alteration of specific nesting, feeding, or other behavioral requirements usually associated with bottomland hardwood forests. Avian use will decline after about five years which is generally associated with decreasing lake fertility, loss of suitable nesting spots (due to death, fall, and decay of inundated timber), and reduced availability of desirable food plants. Those species that inhabit generally open country, prairies, fields brushy plains, roadsides, etc., should suffer very little, if any, detrimental effects. Aquatically oriented species which usually occupy lakes, ponds, mudflats, and shorelines will benefit from the proposed lake.

Mammals. The most seriously affected species will include those associated with the bottomland forest adjacent to the river, such as rabbits and squirrels. The whitetail deer could also be adversely impacted due to a reduction in suitable or preferred habitat. Most terrestrial species will be forced to shift their ranges in accordance with changing water levels. Aquatic species should be benefited and could, as a consequence, experience habitat expansions.

Vegetation. There will be a loss of species within the reservoir area; i.e., aquatic species within the 15 mile reach of the Navasota River, and terrestrial species within the 14,200 acres of the water supply pool. Aquatic vegetation affects environmental factors such as dissolved oxygen, carbon dioxide, ammonia, pH, light penetration, and siltation. Alterations of these factors could cause serious effects such as heavy algae production or eutrophication. Future public and private development around the project and in the downstream area is expected to further reduce existing species. An increase in aquatic plants can be expected along the periphery of the lake. Many of these aquatic species aid in reducing shoreline erosion, and extremely significant to wildlife, and serve as important habitat in the fishery aspect of the lake. In the downstream area, periodic water releases would aid in preserving the existing bottomland species.

Table C-1

VEGETATION COLLECTED IN PROJECT AREA*

Scientific Name	Common Name	Spring Survey		Fall Survey	
		Avg No/Acre	% Composition	Avg No/Acre	% Composition
Callicarpa americana	Mulberry	139	0.4	1,115	6.8
Viburnum rufidulum	Southern Blackhaw	17	0.04	17	0.1
Morus microphylla	Texas Mulberry	1,533	4.2	70	0.4
Rhus aromatica	Fragrant Sumac	35	0.1	331	2.0
Carya texana	Black Hickory	70	0.2	1,167	7.1
Ilex decidua	Possumhaw	6,395	17.4	9,358	57.0
I. vomitoria	Yaupon	22,008	59.9	-	-
Vaccinium arboreum	Farkleberry	1,812	5.0	767	4.7
Ulmus alata	Winged Elm	1,672	4.5	1,533	9.3
Quercus marilandica	Blackjack Oak	-	-	69	0.4
Q. stellata	Post Oak	2,317	6.3	2,004	12.2
Q. laurifolia	Laurel Oak	296	0.8		
Fraxinus pennsylvanica	Red Ash	383	1.0		
Vitis sp.	Grape	35	0.1		
	Unidentified Grass	309,276	7.4	2,774,772	66.2
Paspalum sp.	Paspalum Grass			317,988	7.6
Cenchrus incertus	Coast Sandbur			248,292	5.9
Cynodon dactylon	Bermuda Grass	814,572	19.6	174,240	4.2
Croton sp.	Croton	43,560	1.0	121,968	2.9
Cyperus sp.	Flatsedge			113,256	2.7
Digitaria sp.	Crabgrass			104,544	2.5
Paronychia drummondii	Drummond Nailwort			104,544	2.5
Crusea tricocca	Prairie Crusea			69,696	1.7
Panicum sp.	Panicum	82,764	2.0	69,696	1.7

* Data taken from (SwRI, 1975)

Table C-1 (Continued)

Scientific Name	Common Name	Spring Survey Avg No/Acre	Spring Survey % Composition	Fall Survey Avg No/Acre	Fall Survey % Composition
Polygonum sp.	Smartweed			69,696	1.7
Croptilon divaricatum	Slender Goldenweed			17,424	0.4
Tridens flavus	Purpletop			17,424	0.4
	Unidentified Weeds	470,448	11.3	4,356	0.1
Carex debilis	Spindlefruit Sedge	1,637,856	39.3		
Plantago sp.	Plantain	257,004	6.2		
Pinus taeda	Loblolly Pine	87,120	2.1		
Northoscordum bivalve	Yellow Falsegarlic	74,052	1.6		
Draba brachycarpa	Shortpod Draba	47,916	1.2		
Vicia sp.	Vetch	43,560	1.0		
Oxalis sp.	Woodsorrel	34,848	0.8		
Cerastium glomeratum	Chickweed	30,492	0.7		
Cerastium nutans	Powerhorn Chickweed	4,356	0.1		
HYDROPHYLLACEAE	Waterleaf	21,780	0.5		
Oenothera sp.	Evening Primrose	21,780	0.5		
Rubus trivialis	Southern Dewberry	13,068	0.3		
Krigia sp.	Dandelion	8,712	0.2		
Poa sp.	Bluegrass	8,712	0.2		
Rumex acetosella	Sheep Sorrell	4,356	0.1		
Senecio ampullaceus	Texas Groundsel	4,356	0.1		
Juncus sp.	Rush	4,356	0.1		
Ampelopsis arborea	Peppervine	4,356	0.1		
Chaerophyllum tainturieri	Hairyfruit Chervil	4,356	0.1		

Table C-2

VEGETATION OF NAVASOTA RIVER STUDY AREA*

Trees, Shrubs or Woody Vines

Scientific Name	Common Name
Pinus taeda	Loblolly Pine
Juniperus virginiana	Eastern Redcedar
Yucca louisianensis	Louisiana Yucca
Smilax bona-nox	Bull Briar
Smilax glauca	Cat Greenbriar
Salix nigra	Black Willow
Carya illinoensis	Pecan
Carya texana	Black Hickory
Quercus stellata	Post Oak
Quercus incana	Bluejack
Quercus laurifolia	Laurel Oak
Quercus marilandica	Blackjack Oak
Celtis laevigata	Sugar Hackberry
Ulmus alata	Winged Elm
Ulmus crassifolia	Cedar Elm
Cocculus carolinus	Carolina Snailseed
Rubus trivialis	Southern Dewberry
Gleditsia triacanthos	Common Honeylocust
Zanthoxylum clava-herculis	Herculesclub
Rhus toxicodendron	Poison Oak
Rhus copallina	Flameleaf Sumac
Rhus aromatica	Fragrant Sumac
Ilex vomitoria	Yaupon
Ilex decidua	Possumhaw
Ampelopsis cordata	Heartleaf Ampelopsis
Ampelopsis arborea	Peppervine
Parthenocissus quinquefolia	Virginia Creeper
Vitis mustangensis	Mustang Grape
Vitis aestivalis	Summer Grape
Tilia caroliniana	Carolina Basswood
Ascyrum hypericoides	St. Andrewscross
Opuntia lindheimeri	Texas Pricklypear
Cornus florida	Dogwood
Bumelia lanuginosa	Bumelia
Forestiera acuminata	Swampprivet
Fraxinus pennsylvanica	Red Ash
Callicarpa americana	American Beautyberry
Campsis radicans	Trumpetcreeper
Sambucus canadensis	American Elder
Baccharis angustifolia	Baccharis
Vitis lincecumii	Pinewoods Grape
Morus microphylla	Texas Mulberry

*Data taken from (SwRI, 1975)

Table C-2 (cont.)

Trees, Shrubs or Woody Vines (cont.)

Scientific Name	Common Name
Viburnum rufidulum	Downy Viburnum
Cercis Canadensis	Eastern Redbud
Vaccinium arboreum	Bristleleaf Blueberry
Prosopis glandulosa	Honey Mesquite
Berchemia scandens	Alabama Supple-jack
Prunus rivularis	Creek Plum

Herbaceous Plants Other Than Grasses

Gaillardia aestivalis	Lanceleaf Gaillardia
Helenium amarum	Sneezeweed
Aster dumosus	Bushy Aster
Solidago nemoralis	Dyersweed Goldenrod
Liatris elegans	Pinkscale Gayfeather
Eupatorium coelestinum	Mistflower
Eupatorium serotinum	Late Eupatorium
Gnaphalium purpureum	Purple Cudweed
Verbesina virginica	White Crownbeard
Prionopsis ciliata	Poreleaf
Xanthium strumarium	Cocklebur
Ambrosia psilostachya	Western Ragweed
Ambrosia trifida	Giant Ragweed
Elephantopus carolinianus	Leafy Elephantfoot
Veronia texana	Ironweed
Xanthisma texanum	Texas Sleepydaisy
Heterotheca pilosa	Soft Goldaster
Croptilon divaricatum	Slender Goldenweed
Erigeron philadelphicus	Philadelphia Fleabane
Senecio ampullaceus	Texas Groundsel
Senecio imparipinnatus	Groundsel
Pectis angustifolia	Crownseed Pecter
Berlandiera betonicifolia	Hairy Greeneyes
Sonchus asper	Field Sowthistle
Hymenopappus artemisaefolia	Ragweed Woolywhite
Chaetopoppa asteroides	Leastdaisy
Conyza canadensis	Conyza

Table C-2 (cont.)

Herbaceous Plants: Grasses

Scientific Name	Common Name
Draba brachycarpa	Shortpod Draba
Bothriochloa saccharoides	Silver Bluestem
Aristida purpurea	Purple Threeawn
Poa annua	Annual Bluegrass
Uniola sessilifora	Sea-oats
Arundo donax	Giantreed
Tridens congestis	Pink Tridens
Cenchrus incertus	Coast Sandbur
Elymus virginicus	Virginia Wildrye
Elymus canadensis	Canada Wildrye
Lolium perenne	Perennial Ryegrass
Muhlenbergia cappillaris	Hairyawn Muhly
Muhlenbergia asperifolia	Hairyawn Muhly
Sporobolus contractus	Spike Dropseed
Cynodon dactylon	Bermudagrass
Panicum thurowii	Thurow Panicum
Panicum hians	Gaping Panicum
Panicum lanuginosum	Woolly Panicum
Panicum laxiflorum	Openflower Panicum
Panicum oligosanthes	Scribner Panicum
Setaria lutescens	Yellow Bristlegrass
Andropogon ischaemum	Bluestem
Andropogon scoparius	Bluestem
Paspalum dilatatum	Dallisgrass
Paspalum ciliatifolium	Paspalum
Eragrostis intermedia	Plains Lovegrass
Eragrostis curtipedicillata	Gummy Lovegrass
Eragrostis oxylepis	Red Lovegrass
Sorghum vulgare	Sorghum
Tridens flavus	Purpletop
Digitaria sanguinalis	Hairy Crabgrass
Agrostis elliottiana	Elliot Bentgrass
Festuca octoflora	Fescue
Bromus unioloides	Rescuegrass

Other Herbaceous Plants

Crusea tricocca	Prairie Crusea
Plantago aristata	Bottlebrush
Ludwigia palustris	Marsh Seedbox
Physalis pubescens	Downy Groundcherry
Verbena halei	Slender Verbena
Juncus diffussissimus	Slimpod Rush
Juncus dichotomus	Forked Rush

Table C-2 (cont.)

Other Herbaceous Plants (Cont'd)

Scientific Name	Common Name
Teucrium canadense	American Germander
Salvia lyrata	Lyreleaf Sage
Scutellaria sp.	Skullcap
Rumex crispus	Curly Dock
Rumex pulcher	Fiddle Dock
Croton capitatus	Woolly Croton
Croton glandulosus	Tropic Croton
Croton sp.	Croton
Acalypha gracilens	Slender Copperleaf
Sanicula canadensis	Slender Conperleaf
Hypericum drummondii	Drummond St. Johnswort
Spermolepis divaricata	Forked Scaleseed
Paronychia drummondii	Drummond Nailwort
Cyperus sp. No. 1	Flatsedge
Cyperus sp. No. 2	Flatsedge
Cyperus sp. No. 3	Flatsedge
Torilis nodosa	Knotted Hedgeparsley
Froelichia floridana	Florida Snakecotton
Passiflora incarnata	Maypop Passionflower
Desmodium glabellum	Tickclover
Desmanthus illinoensis	Illinois Bundleflower
Commelina erecta	Erect Dayflower
Baptisia nuttalliana	Nuttall Wildindigo
Symphoricarpus orbiculatus	Coralberry
Phytolacca americana	Common Pokeberry
Cassia fasciculata	Prairie Senna
Petalostemon griseus	Oklahoma Prairieclover
Centrosema virginiana	Butterflypea
Cynanchum laeva	Smooth Swallowort
Cynanchum barbigerum	Bearded Swallowort
Ipomopsis rubra	Texas Plume
Solanum elaeaganifolium	Silverleaf Nightshade
Datura stramonium	Jimson-weed
Ipomoea trichocarpa	Morning Glory
Ruellia humilis	Ruellia
Rhynchosia latifolia	Broadleaf Snoutbean
Sesbania versicaria	Bagpod Sesbania
Cissus incisa	Ivy Treebine
Anemone decapetala	Tenpetal Anemone
Euphorbia bicolor	Snow-on-the-prairie
Euphorbia cordifolia	Heartleaf Euphorbia
Euphorbia romeriana	Roemer Euphorbia

Table C-2 (cont.)

Other Herbaceous Plants (Cont'd)

Scientific Name	Common Name
Croton lindheimerianus	Threeseed Croton
Polygonum aviculare	Prostrate Knotweed
Palafoxia rosea	Rose Palafoxia
Passiflora tenuiloba	Spreadlobe Passionflower
Cnidosculus texanus	Texas Bullnettle
Desmodium sp.	Tickclover
Ascyrum stans	Atlantic St. Peterswort
Elatine triandra	Waterwort
Utricularia inflata	Floating Bladderwort
Hypericum sp.	St. Johnswort
Rumex acetosella	Sheep Sorrel
Hypoxis hirsuta	Common Goldstar
Robinia pseudo-acacia	Black Locust
Phlox drummondii	Drummond Phlox
Phlox pilosa	Downy Phlox
Linaria texana	Texas Toadflax
Castilleja indivisa	Texas Paintbrush
Lupinus subcarinosus	Texas Bluebonnet
Betula nigra	River Birch
Crataegus mollis	Downy Hawthorne
Capsella bursa-pastoris	Shepherds Purse
Salix sp.	Willow
Melilotis indicus	Annual Yellow Sweetclover
Carex frankii	Franks Sedge
Carex oxylepis	Sharpscale Sedge
Carex debilis	Spindlefruit Sedge
Carex tribuloides	Bristlebract Sedge
Carex triangularis	Anglestem Sedge
Carex cherokeensis	Cherokee Sedge
Carex vulpinoidea	Fox Sedge
Carex muhlenbergia	Muhlenberg Sedge
Carex sp.	Sedge
Galium triflorum	Fragrant Bedstraw
Scutellaria drummondii	Drummond Skullcap
Chaerophyllum tainturieri	Hairy-fruit Chervil
Myosotis macrosperma	Spring Forgetmenot
Geum canadense	White Avens
Gaura brachycarpa	Plains Gaura
Cerastium nutans	Powerhorn Chickweed
Cerastium glomeratum	Chickweed

Table C-2 (cont.)

Other Herbaceous Plants(Cont'd)

Scientific Name	Common Name
Nothoscordum bivalve	Yellow Falsegarlic
Allium sp.	Onion
Trifolium bejariense	Bejar Clover
Vicia sp.	Vetch
Tradescantia hirosutiflora	Hairyflower Spiderwort
Scirpus koilolepis	Bulrush
Medicago hispida	Burclover
Viola missouriensis	Missouri Violet
Cirsium horridulum	Yellow Thistle

Table C-3

FISH SPECIES OF THE NAVASOTA RIVER, TEXAS

Scientific Name	Common Name	Sites Collected		
		Project Area*	Project Area#	Navasota River Drainage Area#
Amia calva	Bowfin			X
Lepisosteus spatula	Alligator Gar			X
L. oculatus	Spotted Gar	X		X
L. osseus	Longnose Gar	X		X
Dorosoma cepedianum	Gizzard Shad	X	X	X
D. petenense	Threadfin Shad			X
Esox americanus	Redfin Pickerel	X	X	X
Cyprinus carpio	Carp	X	X	X
Notemigonus chrysoleucas	Golden Shiner	X	X	X
Opsopoedus emiliae	Pugnose Minnow		X	X
Notropis fumeus	Ribbon Shiner	X	X	X
N. shumardi	Silverband Shiner		X	X
N. lutrensis	Red Shiner	X	X	X
N. venustus	Blacktail Shiner			X
N. atrocaudalis	Blackspot Shiner			X
N. buchanani	Ghost Shiner			X
Hybognathus nuchalis	Silvery Minnow		X	X
Pimephales vigilax	Bullhead Minnow	X	X	X
P. promelas	Bluntnose Minnow			X
Campostoma anomalum	Stoneroller			X

Reference note: (*Data taken from Southwest Research Institute, 1975)
(#Data taken from Rozenburg et al., 1972)

Table C-3 (cont.)

Scientific Name	Common Name	Sites Collected		
		Project Area*	Project Area#	Navasota River Drainage Area#
Ictiobus niger	Black Buffalofish		X	X
I. bubalus	Smallmouth Buffalofish			X
Carpiodes carpio	River Carpsucker		X	X
Erimyzon oblongus	Creek Chubsucker			X
Minytrema melanops	Spotted Sucker		X	X
Ictalurus punctatus	Channel Catfish		X	X
I. furcatus	Blue Catfish			X
I. melas	Black Bullhead		X	X
I. natalis	Yellow Bullhead	X		X
Pylodictis olivaris	Flathead Catfish			X
Noturus gyrinus	Tadpole Madtom	X	X	X
Aphredoderus sayanus	Pirateperch	X	X	X
Fundulus notti	Starhead Topminnow			X
F. notatus	Blackstripe Topminnow			X
F. olivaceous	Blackspotted Topminnow	X	X	X
Gambusia affinis	Mosquitofish	X	X	X
Micropterus salmoides	Largemouth Bass	X	X	X
M. punctulatus	Spotted Bass			X
Chaenobryttus gulosus	Warmouth Bass	X	X	X
Lepomis cyanellus	Green Sunfish	X	X	X
L. symmetricus	Bantam Sunfish	X		X
L. punctatus	Spotted Sunfish			X

Table C-3 (cont.)

Scientific Name	Common Name	Sites Collected		
		Project Area*	Project Area#	Navasota River Drainage Area#
L. microlophus	Redear Sunfish		X	X
L. marginatus	Dollar Sunfish	X		X
L. megalotis	Longear Sunfish		X	X
L. humilis	Orangespotted Sunfish	X	X	X
L. macrochirus	Bluegill Sunfish	X	X	X
Pomoxis annularis	White Crappie	X	X	X
P. nigromaculatus	Black Crappie			X
Elassoma zonatum	Banded Pygmy Sunfish			X
Percina sciera	Dusky Darter	X	X	X
Percina sp.	Logperch	X		X
Etheostoma chlorosomum	Bluntnose Darter	X	X	X
E. parvipinne	Goldstripe		X	X
E. gracile	Slough Darter		X	X
Aplodinotus grunniens	Freshwater Drum			X

Table C-4

BIRD SPECIES SIGHTED IN THE STUDY AREA*

Scientific Name	Common Name	Habitat		
		Prairie	Forest	Forest/ Prairie
Ardea herodias	Great Blue Heron	UN	-	Com
Florida caerulea	Little Blue Heron	-	-	UN
Butorides vivescens	Green Heron	UN	-	UN
Bulbulcus ibis	Cattle Egret	UN	-	UN
Branta canadensis	Canada Goose	UN	-	Com
Anser albifrons	White-Fronted Goose	UN	-	UN
Chen hyperborea	Snow Goose	-	-	Com
Anas platyrhynchos	Mallard	Com	-	-
A. strepera	Gadwall	-	-	UN
A. acuta	Pintail	-	-	UN
Cathartes aura	Turkey Vulture	Ab	Com	Ab
Coragyps atratus	Black Vulture	UN	-	UN
Buteo jamaicensis	Red-Tailed Hawk	Com	-	UN
B. lineatus	Red-Shouldered Hawk	+	-	-
Circus cyaneus	Marsh Hawk	-	-	UN
Caracara cheriway	Caracara	+	-	-
Falco peregrinus	Peregrine Falcon	-	-	UN
Falco columbarius	Pigeon Hawk	UN	-	-
Falco sparverius	Sparrow Hawk	UN	-	UN
Colinus virginianus	Bobwhite	UN	-	Com
Meleagris gallopavo	Turkey	UN	-	-
Chapadrius vociferus	Killdeer	Com	-	Com
Pluvialis dominica	American Golden Plover	-	-	UN
Capella gallinago	Common Snipe	-	-	UN
Bartramia longicauda	Upland Plover	Com	-	-
Totanus flavipes	Lesser Yellowlegs	-	-	Com
Calidris fuscicollis	White-Rumped Sandpiper	-	-	Com
Columba livia	Domestic Pigeon	+	-	-
Zenaida macroura	Mourning Dove	Com	-	Com
Scadafella inca	Inca Dove	Com	-	UN
Bubo virginianus	Great Horned Owl	-	UN	-
Chaetura pelagica	Chimney Swift	Com	-	-
Archilochus alexandri	Black-Chinned Hummingbird	-	-	UN
Megaceryle alcyon	Belted Kingfisher	-	-	UN
Colaptes auratus	Yellow-Shafted Flicker	-	-	UN
Colaptes cafer	Red-Shafted Flicker	UN	-	UN
Centurus carolinus	Red-Bellied Woodpecker	UN	-	UN
C. aurifron	Golden-Fronted Woodpecker	UN	-	-
Melanerpes erythrocephalus	Red-Headed Woodpecker	-	-	UN
Sphyrapicus varius	Yellow-Bellied Sapsucker	-	UN	UN
Dendrocopos villoscens	Hairy Woodpecker	-	-	UN
D. pubescens	Downy Woodpecker	UN	UN	UN

*Data taken from (SwRI, 1975)

Table C-4 (cont.)

Scientific Name	Common Name	Habitat		
		Prairie	Forest	Forest/ Prairie
Tyrannus tyrannus	Eastern Kingbird	Com	-	UN
Muscivora forficata	Scissor-Tailed Flycatcher	Com	-	UN
Sayornis phoebe	Eastern Phoebe	-	-	UN
Empidonax flaventris	Yellow-Bellied Flycatcher	+	-	-
Eremophila alpestris	Horned Lark	UN	-	-
Hirunda rustica	Barn Swallow	UN	-	Com
Progne subis	Purple Martin	UN	-	UN
Cyanocitta cristata	Blue Jay	UN	UN	Com
Corvus brachyrhynchos	Common Crow	Com	Com	Com
Parus carolinensis	Carolina Chickadee	-	Com	UN
Parus bicolor	Tufted Titmouse	-	Com	Com
Mimus polyglottos	Mockingbird	Com	Com	Com
Toxostoma rufum	Brown Thrasher	UN	Com	UN
Turdus migrator	Robin	Ab	UN	Com
Hylocichla fuscescens	Veery	UN	-	UN
Sialia sialis	Eastern Bluebird	Com	-	UN
Sialia mexicana	Western Bluebird	-	-	UN
Polioptila caerulea	Blue-Gray Gnatcatcher	-	-	UN
Regulus calendula	Ruby-Crowned Kinglet	-	UN	UN
Bombycilla cedrorum	Cedar Waxwing	+	-	-
Lanius ludovicianus	Loggerhead Shrike	Com	-	UN
Sturnus vulgaris	Starling	Com	-	Com
Vireo bellii	Bell's Vireo	-	-	UN
Vireo solitarius	Solitary Vireo	-	Com	UN
Dendroica coronata	Myrtle Warbler	-	-	UN
Passer domesticus	House Sparrow	Com	Com	UN
Dolichonyx oryzivorus	Bobolink	UN	-	UN
Sturnella magna	Eastern Meadowlark	Ab	-	Com
Euphagus cyanociphalus	Red-Winged Blackbird	UN		Com
Euphagus carolinus	Rusty Blackbird	UN		UN
E. cyanocephalus	Brewer's Blackbird	Ab	Com	Ab
Cassidix mexicanus	Boat-Tailed Grackle	UN	-	Com
Quiscalus quiscula	Common Grackle	Com	-	Com
Molothrus ater	Brown-Headed Cowbird	UN	-	UN
Richmondena cardinalis	Cardinal	Com	Com	Com
Spiza americana	Dickcissel	Com	UN	UN
Passerculus sandwichensis	Savannah Sparrow	Com	-	Com
Ammodramus savannarum	Grasshopper Sparrow	UN	-	-
Passerherbulus caudacutus	Le Contis Sparrow	+	-	-
Pooecetes gramineus	Vesper Sparrow	Com	-	-
Aimophila aestivalis	Bachman's Sparrow	-	-	Com
Aimophila cassinii	Cassin's Sparrow	Com	-	-
Junco hyemalis	Slate-Colored Junco	-	Com	Com

Table C-4 (cont.)

Scientific Name	Common Name	Habitat		
		Prairie	Forest	Forest/ Prairie
Zonotrichia querula	Harris Sparrow	Com	-	Com
Z. leucophrys	White-Crowned Sparrow	UN	-	UN
Melospiza lincolni	Lincoln's Sparrow	Com	-	UN
Passerella iliaca	Fox Sparrow	+	-	-
Melospiza melodia	Song Sparrow	Com	-	Com
Coccyzus americanus	Yellow-Billed Cuckoo	+	-	-
Geococcyx californianus	Roadrunner	+	-	-
Phalaenoptilus nuttallii	Whip-poor-will	+	-	-
Chordeiles minor	Common Nighthawk	+	-	-
Sitta carolinensis	White-Breasted Nuthatch	+	-	-
Dumetella carolinensis	Catbird	UN	-	-
Vireo gilvus	Warbling Vireo	UN	-	-
Chondestes grammacus	Lark Sparrow	UN	-	-
Zonotrichia albicollis	White-Throated Sparrow	-	-	Com
Dendroica castanea	Bay Breasted Warbler	-	Com	-
Spinus tristis	American Goldfinch	-	UN	-
Carpodacus purpureus	Purple Finch	-	-	UN

LEGEND:

+	Sighted in previous survey
Ab	Abundant-100 or more seen in a day
Com	Common-5 to 100 seen in a day
UN	Uncommon-less than 5 in a day
R	Rare-1 to 5 in a year

Table C-5

MAMMALS IN THE STUDY AREA

Scientific Name	Common Name	Reference for Occurrence (SwRI,1975*)	(Davis,1974)
Sylvilagus floridanus	Cottontail	x	x
Sciurus carolinensis	Gray Squirrel	x	x
Procyon lotor	Raccoon	x	x
Canis latrans	Coyote	x	x
Lynx rufus	Bobcat	x	x
Didelphis virginiana	Opossum	x	x
Spilogale putorius	Spotted Skunk	x	x
Mephitis mephitis	Striped Skunk	x	x
Dasypus novemcinctus	Armadillo	x	x
Castor canadensis	Beaver	x	x
Odocoileus virginianus	White-Tailed Deer	x	x
Myocaster coypus	Nutria	x	x
Sciurus niger	Fox Squirrel	x	x
Sigmodon hispidus	Hispid Cotton Rat	x	x
Geomys bursarius	Plains Pocket Gopher	x	x
Spermophilus tridecemlineatus	13-Lined Ground Squirrel	x	x
Lepus californicus	California Jackrabbit	x	x
Scalopus aquaticus	Eastern Mole		x
Cryptotis parva	Least Shrew		x
Pipistrellus subflavus	Georgia Bat		x
Eptesicus fuscus	Big Brown Bat		x
Lasiurus borealis	Red Bat		x
Nycticeius humeralis	Evening Bat		x
Tadarida mexicana	Guano Bat		x
Bassariscus astutus	Ringtail		x
Mustela frenata	Long-Tailed Weasel		x
M. vison	Mink		x
Taxidea taxus	Badger		x
Vulpes fulva	Red Fox		x
Urocyon cinereoargenteus	Gray Fox		x
Glaucomys volans	Eastern Flying Squirrel		x
Perognathus hispidus	Hispid Pocket Mouse		x
Reithrodontomys fulvescens	Fulvous Harvest Mouse		x
R. montanus	Plains Harvest Mouse		x
Baiomys taylori	Pygmy Mouse		x
Peromyscus maniculatus	Deer Mouse		x
P. leucopus	White-Footed Mouse		x
P. gossypinus	Cotton Mouse		x
Neotoma floridana	Florida Wood Rat		x
Sylvilagus aquaticus	Swamp Rabbit		x

* Species noted by sightings, tracks, & other signs

Table C-6

AMPHIBIANS AND REPTILES IN THE STUDY AREA

Scientific Name	Common Name	Reference for Occurrence (SwRI, 1975)	Reference for Occurrence (Raun and Gehlbach, 1972)
Siren intermedia	Lesser Siren		x
Ambystoma texanum	Small-mouthed Salamander		x
Notophthalmus viridescens	Common Newt		x
Eurycea quadridigitata	Dwarf Salamander		x
Scaphiopus holbrooki	Eastern Spadefoot		x
Acris crepitans	Cricket Frog	x	x
Hyla cinera	Green Treefrog	x	x
H. crucifer	Spring Peeper		x
H. versicolor	Northern Gray Treefrog		x
H. chrysoscelis	Southern Gray Treefrog		x
Pseudacris clarki	Spotted Chorus Frog		x
P. streckeri	Strecker's Chorus Frog		x
P. triseriata	Western Chorus Frog		x
Bufo speciosus	Texas Toad	x	x
B. valliceps	Gulf Coast Toad		x
B. woodhousei	Woodhouse's or Fowler's Toad	x	x
Rana catesbeiana	Bullfrog	x	x
R. clamitans	Green or Bronze Frog	x	x
R. palustris	Pickerel Frog		x
R. pipiens	Leopard Frog	x	x
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad		x
G. olivacea	Great Plains Narrow-mouthed Toad		x
Chelydra serpentina	Snapping Turtle		x
Kinosternon subrubrum	Eastern Mud Turtle		x
Sternothaerus carinatus	Keel-backed Musk Turtle		x
S. odoratus	Stinkpot		x
Chrysemys concinna	Texas Slider or River Cooter	x	x
C. scripta	Pond Slider or Red Ear Turtle	x	x
Deirochelys reticularia	Chicken Turtle		x
Graptemys pseudogeographica	Map Turtle		X
Terrapene carolina	Eastern Box Turtle	x	x
T. ornata	Western or Ornate Box Turtle	x	x
Trionyx muticus	Smooth Softshell		x
T. spiniferus	Spring Softshell	x	x
Alligator mississippiensis	Alligator		x

Table C-6 (cont.)

Scientific Name	Common Name	Reference for Occurrence (SwRI,1975)	Reference for Occurrence (Raun and Gehlbach,1972)
Anolis carolinensis	Green Anole	x	x
Phrynosoma cornutum	Texas Horned Lizard		x
Sceloporus olivaceus	Texas Spiny Lizard	x	
Sceloporus undulatus	Fena Lizard	x	x
Eumeces fasciatus	Five-lined Skink		x
E. laticeps	Broad-headed Skink		x
E. septentrionalis	Prairie Skink		x
Lygosoma laterale	Ground Skink	x	x
Cnemidophorus gularis	Texas Spotted Whiptail		x
C. sexlineatur	Six-lined Racerunner	x	x
Leptotyphlops dulcis	Texas Blind Snake		x
Arizona elegans	Glossy Snake		x
Coluber constrictor	Racer		x
Elaphe obsoleta	Rat Snake		x
Farancia abacura	Mud Snake		x
Heterodon nasicus	Western Hognose Snake		x
H. platyrhinos	Eastern Hognose Snake		x
Lampropeltis getulus	Kingsnake		x
L. triangulum	Milk Snake		x
Masticophis flagellum	Coachwhip		x
Natrix erythrogaster	Plain-bellied Water Snake		x
N. fasciata	Broad-banded Water Snake		x
N. grahami	Graham's Water Snake	x	x
N. rhombifera	Diamond-backed Water Snake		x
N. rigida	Glossy Water Snake		x
Opheodrys aestivus	Rough Green Snake		x
Storeria dekayi	Brown Snake		x
Tantilla gracilis	Flat-headed Snake		x
Thamnophis proximus	Western Ribbon Snake	x	x
Virginia striatula	Rough Earth Snake		x
V. valeriae	Smooth Earth Snake		x
Micrurus fulvius	Coral Snake		x
Agkistrodon contortrix	Copperhead		x
A. piscivoris	Cottonmouth	x	x
Sistruus millarius	Pygmy Rattlesnake		x
Crotalus atrox	Western Diamondback Rattlesnake		x
C. horridus	Timber Rattlesnake		x

Table C-7

Taxonomic List of
Aquatic Organisms Collected from the Navasota River*

Kingdom Monera

Phylum Schizophyta (Bacteria)
Order Pseudomonadales
Family Rhodobacteriaceae
Rhodospirillum sp.

Family Pseudomonadaceae
Pseudomonas sp.
Xanthomonas sp.

Family Spirillaceae
Vibrio sp.

Order Eubacteriales
Family Achromobacteraceae
Alcaligenes sp.
Achromobacter sp.
Flavobacterium sp.

Family Rhizobiaceae
Chromobacterium sp.

Phylum Cyanophyta (Blue-greens)
Class Myxophyceae
Order Chroococcales
Anacystis sp.
Aphanocapsa sp.
Aphanothece sp.
Chroococcus sp.
Dactylococcopsis sp.
Gloeocapsa sp.
Merismopedia sp.
Microcystis sp.
Synechococcus sp.

Order Chamaesiphonales
Chamaesiphon sp.

Order Hormogonales
Anabaena sp.
Anabaenopsis sp.
Arthrospira sp.
Aulosira sp.

* - reference note: data taken from Clark (1973).

Table C-7 (cont.)

Lyngbya sp.
Nostoc sp.
Osclatoria sp.
Phormidium sp.
Plectonema sp.
Scytonema sp.
Stigonema sp.
Spirulina sp.

Kingdom Protista

Phylum Euglenophyta (Euglenas)
Order Euglenales
Euglena sp.
Phacus sp.
Trachelomonas sp.

Phylum Chlorophyta (Green algae)
Class Chlorophyceae
Order Volvocales
Chlamydomonas sp.
Eudorina sp.
Pandorina sp.
Volvox sp.

Order Tetrasporales
Dactylothece sp.
Sphaerocystis sp.

Order Chlorococcales
Actinastrum sp.
Ankistrodesmus sp.
Characium sp.
Chlorella sp.
Chlorochytrium sp.
Crucigenia sp.
Dictyosphaerium sp.
Golenkinia sp.
Lagerheimia sp.
Oocystis sp.
Pediastrum sp.
Planktosphaeria sp.
Scenedesmus sp.
Tetraedron sp.
Treubaria sp.

Table C-7 (cont.)

Order Zygnematales
- Closterium sp.
- Cosmarium sp.
- Mesotaenium sp.
- Mougeotia sp.
- Penium sp.
- Sirogonium sp.
- Spirogyra sp.
- Zygnema sp.

Order Ulotrichales
- Chaetophora sp.
- Hormidiopsis sp.
- Microspora sp.
- Protococcus sp.
- Ulothrix sp.
- Uronema sp.

Order Oedogoniales
- Oedogonium sp.

Order Cladophorales
- Cladophora sp.
- Rhizoclonium sp.

Class Charophyceae
Order Charales
- Chara sp.

Phylum Chrysophyta (Diatoms and others)
Class Xanthophyceae
Order Rhizochiroidales
- Stipitococcus sp.

Order Heterococcales
- Arachnochloris sp.

Order Heterotrichales
- Tribonema sp.

Order Heterosiphonales
- Vaucheria sp.

Class Chrysophyceae
Order Chrysomonadales
- Mallomonas sp.
- Synura sp.

Table C-7 (cont.)

Order Chloromonadales
Merotrichia sp.

Class Bacillariophyceae
Order Centrales
Cyclotella sp.
Melosira sp.
Stephanodiscus sp.

Order Pennales
Achnanthes sp.
Amphora sp.
Asterionella sp.
Caloneis sp.
Campylodiscus sp.
Centronella sp.
Cocconeis sp.
Cymbella sp.
Diatoma sp.
Diatomella sp.
Diploneis sp.
Eunotia sp.
Fragillaria sp.
Gomphoneis sp.
Gyrosigma sp.
Mastogloia sp.
Navicula sp.
Neidium sp.
Nitzschia sp.
Opephora sp.
Pleurosigma sp.
Pinnularia sp.
Stauroneis sp.
Surirella sp.
Synedra sp.

Phylum Protozoa
Class Mastigophora
Order Euglenoidina
Family Astasiidae
Astasia sp.
Entosiphon sp.

Class Sarcodina
Order Testacea
Family Arcellidae
Arcella sp.

Table C-7 (cont.)

Family Diflugiidae
Difflugia sp.

Class Ciliata
Order Holotrichia
Family Colepidae
Coleps sp.

Family Paramecidae
Paramecium sp.

Family Stentoridae
Stentor sp.

Order Spirotrichia
Family Oxytrichidae
Stylonchia sp.

Family Euplotidae
Euplotes sp.

Order Peritrichia
Family Vorticellidae
Vorticella sp.

Kingdom Metazoa

Phylum Platyhelminthes (Flatworms)
Class Turbellaria (Planarians)
Order Tricladida
Family Planariidae
Curtisia foremani

Class Trematoda
Order Digenea
Family Macroderoidae
Macroderoides spiniferus
Paramacroderoides echinus

Class Cestoda
Order Proteocephala
Family Protocephalidae
Protocephalus sp.

Phylum Nematoda
Order Spiruridea
Family Cucullanidae
Dichelyne lepisosteus

Table C-7 (cont.)

Order Ascaridida
Family Heterocheilidae
Contracaeum spiculigerum

Phylum Rotifera (Rotifers) Many species of aloricate rotifers found
Class Monogononta which could not be identified from preserved material.
Order Pliona
Family Branchionidae
Branchionus angularis
B. bidentata
B. calyciflorous
B. havaenesis
B. quadridenta
Euchlanis sp.
Kellicottia longispina
K. bostoniensis
Keratella cochlearis
K. valga
K. spp.
Lepadella sp.
Notholca sp.
Platyias patulus
P. polyacanthus
P. quadricornis

Family Lecanidae
Lecane sp.
Monostyla sp.

Family Gastropidae
Ascomorpha sp.

Family Trichocercidae
Trichocera sp.

Family Asplanchinidae
Asplanchna sp.

Family Synchaetidae
Polyartha sp.
Synchaeta sp.

Order Flosulariaceae
Family Testudinellidae
Filinia sp.
Trochosphera sp.

Table C-7 (cont.)

Family Hexarthridae
Hexartha sp.

Phylum Ectoprocta
Class Phylactolaemata (Bryozoans, moss animals)
Order Plumatellina
Family Plumatellidae
Plumatella sp.

Phylum Annelida
Class Oligochaeta (Earthworms)
Order Opisthopora
Family Lumbricidae
Lumbriculus sp.

Order Plesiopora
Family Enchytraeidae
Enchytraeus sp.

Class Hirudinea (Leeches)
Order Rhychobdellida
Family Glossiphoniidae
Glossiphonia sp.
Placobdella sp.
P. rugosa
P. parasitica

Family Erpobdellidae
Erpobdella punctata

Phylum Arthropoda
Class Arachnoidea
Order Hydracarina (Water mites)
Unidentified spp.

Class Crustacea
Sub-Class Branchiopoda
Order Anostraca (Fairy shrimp)
Family Streptocephalidae
Streptocephalus seali

Order Conchostraca (Clam shrimp)
Family Leptestheriidae
Leptestheria compleximanus

Order Cladocera (Water fleas)
Family Sididae
Diaphanosoma brachyurum

Table C-7 (cont.)

Family Daphinidae
Ceriodaphnia lacustris
C. pulchella
C. quadriangula
C. rigaudi

Family Moinidae
Moina micrura

Family Bosminidae
Bosmina coregoni
B. longirostris
B. longirostris var. cornuta

Family Macrothrieidae
Ilyocryptus sordidus
I. spinnjfer
Macrothrix laticornis

Family Chyoridae
Alona affinis
A. karva
A. rectangula
Camptocercus oklahomensis
C. rectirostris

Sub-Class Ostracoda
Order Podocopa (Seed shrimp)
Unidentified spp.

Sub-Class Copepoda (Copepods)
Order Eucopepoda
Family Diaptomidae
Diaptomus dorsalis
D. pallidus
D. siciloides

Family Cyclopidae
Cyclops exilis
C. vernalis
Ectocyclops phaleratus
Eucyclops agilis
E. speratus
Paracyclops fimbriatus poppei
Tropocyclops parsinus

Family Ergasilidae
Ergasilus chautauquensis

Table C-7 (cont.)

Family Lernaeidae
Lernaea sp.

Order Isopoda (Aquatic sow bugs)
Family Asellidae
Asellus sp.
Lirceus sp.

Order Amphipoda (Scuds, Sideswimmers)
Family Talitridae
Hyalella azteca

Order Decapoda (Freshwater shrimps, Crayfish)
Family Astacidae
Subfamily Cambarinae
Cambarus diogenes ludovicianus
Fallicambarus hedgpethi
Orconectes palmeri longimanus
Procambarus acutus
P. clarki
P. curdi
P. incilis
P. simulans

Subfamily Cambarellinae
Cambarellus puer

Family Palaemonidae
Palaeomonetes kadiakensis

Class Insecta
Order Collembola (Springtails)
Family Smynthruidae
Smynthruides sp.

Order Ephemeroptera (Mayflies)
Family Baetidae
Baetis sp.
Callibaetis sp.
Centrophilum sp.
Cloeon sp.
Pseudocloen sp.
Neocloeon
Tricorythodes sp.

Family Ephemeridae
Hexagenia limbata venusta
Pentagenia vittigera

Table C-7 (cont.)

Family Heptageniidae
Stenonema spp.
S. interpunctatum canadense

Family Caenidae
Brachycercus sp.
Caenis sp.

Family Polymitarcidae
Campsurus sp.
Tortopus sp.

Family Siphlonuridae
Ameletus sp.
Isonychia rufa

Order Odonata (collected and identified as adults)
Suborder Anisoptera (Dragonflies)
Family Gomphidae
Ariogaomphus lentulus
Dromogomphus armatus
D. spinosus
D. spoliatus
Erpetogomphus compositus
E. designatus
Gomphoides stigmatus
Gomphurus externus
G. militaris
G. vastus
Hagenius brevistylyus
Ophiogomphus sp.
Progomphus borealis
P. obscurus
Stylurus plagiatus

Family Libellulidae
Celithemis elisa
C. epoinina
Dythemis fugax
D. velox
Epicordulia sp.
Erythemis simplicollis
Erythrodiplax berenice
E. minuscula
E. umbrata
Libellula auripennis
L. commanche

Table C-7 (cont.)

L. flavida
L. incesta
L. luctosa
L. pulchella
L. subornata
L. vibrans
Neurocordulia sp.
Orthemis ferruginea
Pachydiplax longipennis
Palothemis sp.
Pantala flavescens
P. hymenea
Perithemis tenera
Plathemis lydia
Tarnetrum corruptum
Sympetrum ambiguum
S. linearis
Trama carolina
T. lacertae
T. onusta

Family Macromidae
Didymops transversa
Macromia georgina
M. taeniolata

Family Aeshnidae
Anax junius
Boveria vinosa
Nasiaeshna pentacantha

Family Cordulegasteriidae
Cordulegaster sayi

Suborder Zygoptera (Damselflies)
Family Agrionidae - Calopteryidae
Calopteryx maculata
Hetaerina americana
H. titia

Family Lestidae
Lestes disjuntus australis

Family Coenagrionidae
Amphiagrion sp.
Anomalagrion hastatum
Argia apicalis
A. fumipennis violacea

Table C-7 (cont.)

A. immunda
A. moesta
A. nahuana
A. sedula
A. tibialis
A. translata
Chromagrion sp.
Enallagma basidens
E. civile
E. divagans
E. exsulans
E. signatus
Ischnura posita
I. ramburi
Nehalennia sp.
Telebasis salva

Order Plecoptera (Stoneflies)
Family Perlidae
Perlesta placida

Family Perlodidae
Isoperla sp.

Family Nemouridae
Taeniopteryx titia

Order Hemiptera (True bugs)
Family Naucoridae
Pelocoris sp.

Family Notonectidae
Buenoa sp.
Notonecta sp.

Family Hydrometridae
Hydrometra sp.

Family Belostomatidae
Abedus sp.
Belostoma sp.
Benacus griseus

Family Pleidae
Plea striola

Family Nepidae
Ranatra sp.

Table C-7 (cont.)

Family Corixidae
Corbella edullus
Graptocorixa sp.
Palmacorixa buenoi
Trichocorixa calva
T. kanza
T. louisianae

Family Hebridae
Hebrus consolidus
Merragata sp.
M. hebroides

Family Gerridae
Gerris sp.
Limnogonus sp.
Rheumatobaetes sp.
R. hungerfordi
R. rileyi
R. tenuipes
Trepobates subnitidus

Family Gelastocoridae
Gelastocoris oculatus oculatus

Family Mesoveliidae
Mesovelia amoena
M. mulsanti

Order Neuroptera (Spongillaflies)
Family Sialidae
Sialis sp.

Order Megaloptera (Dobsonflies)
Family Corydalidae
Chauliodes sp.
Corydalus cornutus

Order Coleoptera (Beetles)
Family Dytiscidae
Ababus
Agabaʻes sp.
Bidessus sp.
Comptotomus sp.
C. interogotus
Copelatus sp.
C. chevrolati
Derovatellus sp.
Hydrocanthus sp.

Table C-7 (cont.)

Hydroporus dimidiatus
Laccodytes sp.
Laccophilus proximus
Laccornus sp.
Oreodytes sp.
Thermonectus ornaticolis

Family Hydrophilidae
Anacaena sp.
Berosus infuscatus
B. peregrinus
Cymbiodyta sp.
Enochrus spp.
E. pygaes
Helochares sp.
H. maculiocollis
Helophorus sp.
Hydrobius sp.
Hydrochara sp.
Hydrochus sp.
Hydrophilus sp.
Laccobius sp.
Peracymus sp.
Tropisternus sp.
T. lateralus nimbatus
T. mexicanus

Family Gyrinidae
Dineutes sp.
Gyretes sp.
Gyrinus sp.

Family Elmidae
Dubiraphia sp.
Stenelmis sp.

Family Haliplidae
Haliplus spp.
H. triopsis
Peltodytes spp.

Family Dryopidae
Helichus sp.

Family Noteridae
Hydrocanthus sp.

Table C-7 (cont.)

Family Chrysomelidae
Donacia sp.

Family Helodidae
Scirtus sp.
Cyphon sp.

Family Omophoronidae
Omophoron nitidum

Order Trichoptera (Caddisflies)
Family Hydropsychidae
Cheumatopsyche spp.
Hydropsyche sp.

Family Psychomyiidae
Neureclipsis sp.
Polycentropus sp.

Family Leptoceridae
Leptocella sp.
Mystacides sp.
Triaenodes sp.

Family Hydroptilidae
Agraylea sp.
Tascobia sp.

Order Diptera (Flies & Midges)
Family Tendipedidae - Chironomidae
Anatopynia sp.
Calospectra sp.
Cardiocladius sp.
Coelotanypus sp.
Hydrobaenus sp.
Lauterborniella sp.
Pentaneura spp.
Polypedilum spp.
Precladius skuse
Prodiamesa sp.
Sphaeromias sp.
Tanytarsus spp.
Tendipes spp.

Family Ceratopogonidae
Alluaudomyia sp.
Culicoides 2 spp.
Dasyhelea sp.
Palpomyia sp.

Table C-7 (cont.)

Family Simuliidae
Unidentified sp.

Family Culicidae
Anopheles sp.
Chaoborus sp.
Culex sp.

Family Stratiomyiidae
Nemotelus sp.
Stratiomys sp.

Family Tabanidae
Chrysops sp.
Tabanus sp.

Family Tipulidae
Erioptera sp.

Phylum Mollusca
Class Gastropoda (Snails)
Subclass Pulmonata
Order Basommatophora
Family Physidae
Physa virgata--Physa anatina

Family Lymnaeidae
Lymnaea sp.

Family Planorbidae
Gyraulus sp.
Helisoma sp.
H. trivolvis lentum

Family Ancylidae
Ferrissia sp.
Helicina arbiculata--Oligyra orbiculata
Mesodon sp.

Class Pelecypoda (Clams and Mussles)
Subclass Eulamellibranchia
Family Unionidae
Amblema costata--A. perplicata
Anodonta imbecilis
Carnunculina parva
C. texasensis
Elliptio sp.
Fusconaia sp.

Table C-7 (cont.)

Lasmigonia complanata
Tritogonia verrucosa
Uniomerus tetralasmus

Subclass Heterodonta
Family Sphaeriidae
Sphaerium striatinum

Phylum Chordata
Class Osteichthyes (Bony fishes)
Order Amiiformes
Family Amiidae
Amia calva, Bowfin

Order Lepisosteiformes
Family Lepisosteidae
Lepisosteus oculatus--L. pruductus, Spotted gar
L. osseus, Longnose gar
L. spatula, Alligator gar

Order Clupeiformes
Family Clupeidae
Dorosoma cepedianum, Gizzard shad
D. petenense, Threadfin shad

Order Salmoniformes
Family Esocidae
Esox americanus, Redfin pickerel

Order Cypriniformes
Family Cyprinidae
Campostoma anomalum, Stoneroller
Cyprinus carpio, Carp
Hybognathus nuchalis, Silvery minnow
Notemigonus crysoleucas, Golden shiner
Notropis atrocaudalis, Blackspot shiner
N. buchanani, Ghost shiner
N. fumeus, Ribbon shiner
N. lutrensis, Red shiner
N. oxyrhynchus, Sharpnose shiner
N. shumardi, Silverband shiner
N. venustus, Blacktail shiner
Opsopoedus emiliae--Notropis emiliae, Pugnose minnow
Pimephales promelas, Bluntnose minnow
P. vigilax, Bullhead minnow

Family Catostomidae
Carpiodes carpio, River carpsucker
Erimyzon sucetta, Lake chubsucker
Ictiobus bubalus, Smallmouth buffalo fish
I. niger, Black buffalo fish
Minytrema melanops, Spotted sucker

Order Siluriformes
Family Ictaluridae
Ictalurus furcatus, Blue catfish
I. melas, Black bullhead
I. natalis, Yellow bullhead
I. punctatus, Channel catfish
Noturus gyrinus, Tadpole madtom
Pylodictis olivaris, Flathead catfish

Order Percopsiformes
Family Aphredoderidae
Aphredoderus sayanus, Pirateperch

Order Atheriniformes
Family Cyprinodontidae
Fundulus notatus, Blackstripe topminnow
F. notti, Starhead topminnow
F. olivaceus, Blackspotted topminnow

Family Poeciliidae
Gambusia affinis, Mosquitofish

Family Percichthyidae
Roccus chrysops--Morone chrysops, White bass

Order Perciformes
Family Centrarchidae
Chaenobryttus gulosus--Lepomis gulosus, Warmouth sunfish
L. cyanellus, Green sunfish
L. humilis, Orangespotted sunfish
L. macrochirus, Bluegill sunfish
L. marginatus, Dollar sunfish
L. megalotis, Longear sunfish
L. microlophus, Redear sunfish
L. punctatus, Spotted sunfish
L. symmetricus Bantam sunfish
Micropterus punctulatus, Spotted bass
M. salmoides, Largemouth bass
Pomoxis nigromaculatus, Black crappie
P. annularis, White crappie

Table C-7 (cont.)

Family Elassomatidae
Elassoma zonatum, Banded pigmy sunfish

Family Percidae
Etheostoma chlorosomum, Bluntnose darter
E. gracile, Slough darter
E. parvipinne, Goldstripe darter
Percina macrolepida, Logperch
P. sciera, Dusky darter

Family Sciaenidae
Aplodinotus grunniens, Freshwater drum

The following species are in the Texas A&M University Cooperative Wildlife Collection with collection locations in the Navasota River drainage, but were not collected during this project.

Astyanax fasciatus, Banded tetra
Hybopsis destivalis, Speckled chub
Labidesthes sicculus, Brook silversides
Lepomis auritus, Redbreast sunfish
Notropis amablish, Texas shiner
N. aminis, Pallid shiner
N. texanus, Weed shiner

Table C-8

Benthic Organisms of the Navasota River *

Organisms	Occurrence												Other Tributaries
	River			Cedar			Brushy			Holland			
	U	M	L	U	M	L	U	M	L	U	M	L	
Platyhelminthes													
Turbellaria													
Curtisia foremani										x			
Annelida													
Oligochaeta													
Lumbriculus	x			x						x			
Enchytraeus							x						
Hirudinea													
Plaxobdella sp.	x	x		x	x	x		x					
P. rugosa				x									
P. parasitica								x					
Glossiphonia spp.													x
Erpobdella punctata							x	x					x
Arthropoda													
Crustacea													
Conchostraca													
Leptestheria compleximanus			x										
Amphipoda													
Hyalella azteca	x			x			x	x					x
Decapoda													
Cambarus diogenes ludovicianus	x												x
Fallicambarus hedgepethi								x					
Orconectes palmeri longimanus					x								
Procambarus curdi		x											
P. acutus	x												x
P. clarki	x		x		x								x
P. simulans	x		x										x
P. incilis								x					x
Palaemonetes kadiakensis	x	x	x	x		x	x	x	x		x		

* - reference note: data taken from Clark (1973).

Table C-8 (cont.)

Benthic Organisms of the Navasota River

Organisms	Occurrence														
	River			Cedar			Brushy			Holland			Other Tributaries		
	U	M	L	U	M	L	U	M	L	U	M	L			
Platyhelminthes															
Turbellaria															
Curtisia foremani										x					
Annelida															
Oligochaeta															
Lumbriculus	x			x						x					
Enchytraeus							x								
Hirudinea															
Plaxobdella sp.	x	x		x	x	x		x							
P. rugosa				x											
P. parasitica								x							
Glossiphonia spp.															x
Erpobdella punctata							x	x							x
Arthropoda															
Crustacea															
Conchostraca															
Leptestheria compleximanus			x												
Amphipoda															
Hyalella azteca	x			x			x	x							x
Decapoda															
Cambarus diogenes ludovicianus	x														x
Fallicambarus hedgepethi								x							
Orconectes palmeri longimanus				x											
Procambarus curdi		x													
P. acutus	x														x
P. clarki	x		x	x											x
P. simulans	x		x												x
P. incilis								x							x
Palaemonetes kadiakensis	x	x	x	x		x	x	x	x		x				

Organisms	Occurrence												
	River			Cedar			Brushy			Holland			Other Tributaries
	U	M	L	U	M	L	U	M	L	U	M	L	
Insecta													
Collembola													
Smynthurides sp.				x		x							
Ephemeroptera													
Baetis sp.	x			x							x		x
Callibaetis sp.	x			x	x				x				x
Centrophilum sp.	x								x		x		x
Cloeon sp.	x		x					x					
Pseudocloeon sp.									x				
Neocloeon sp.			x			x							
Tricorythodes sp.			x			x							
Hexagenis limbata venusta	x	x	x	x	x	x	x	x	x	x	x		x
Stenonema sp.	x	x	x		x	x		x				x	x
S. interpunctatum canadense			x					x					
Caenis sp.	x	x	x	x	x	x	x	x	x	x	x	x	x
Isonychia rufa	x	x	x		x	x							
Ameletus sp.						x							
Odonata (adults)													
Anisoptera													
Progomphus obscurus	x	x		x		x					x		x
Erpetogomphus designatus			x	x		x					x		
Dromogomphus spinosus				x	x	x							x
D. spoliatus	x	x	x					x					
Gomphurus vastus						x						x	
Gomphoides stigmatus	x			x									x
Erythemis simplicicollis	x	x	x	x	x	x	x	x	x	x	x	x	x
Pachydiplax longipennis	x	x	x	x	x	x	x	x	x	x	x	x	x
Pantala flavescens			x	x				x		x			x
Celithemis epoinina													x
C. elisa				x			x				x		
Perithemis tenera	x			x			x	x					x
Libellula commanche		x		x				x		x			x
L. luctosa	x	x	x	x			x	x	x	x	x	x	x

Table C-8 (cont.)

Organisms	Occurrence														
	River			Cedar			Brushy			Holland			Other Tributaries
	U	M	L	U	M	L	U	M	L	U	M	L	
L. flavida				x						x			x
L. incesta		x	x	x			x	x	x				x
L. vibrans	x		x	x			x		x				
L. pulchella			x	x	x								
Plathemis lydia	x	x		x	x		x	x	x	x		x	x
Dythemis fugax	x									x			x
D. velox	x		x	x							x		x
Tarnetrum corruptum		x											
Tramea onusta													x
T. lacertae								x	x	x			
Pantala hymenea				x				x					
Orthemis ferruginea	x			x									x
Sympetrum ambiguum			x	x	x					x	x		x
S. linearis							x		x				
Erythrodiplax minuscula		x	x	x				x					
Didymops transversa					x								x
Nasiaeshna pentacantha					x	x			x				
Anax junius			x	x				x					x
Boyeria vinosa				x	x			x					
Zygoptera (adults)													
Calopteryx maculata			x		x		x	x	x		x		x
Hetaerina titia		x	x	x	x						x		x
H. americana		x	x								x	x	x
Lestes disjuntus australis			x	x			x						x
Argia sedula	x	x	x	x							x	x	x
A. tibialis	x		x	x	x	x		x	x		x		x
A. translata	x									x			x
A. apicalis	x	x	x						x		x	x	x
A. immunda				x							x		x
A. nahuana				x									
A. moesta	x	x	x		x	x						x	x
A. fumipennis violacea		x		x							x	x	x
Ischnura posita		x		x		x							x
I. ramburi		x	x	x		x						x	
Telebasis salva		x		x	x			x			x		x
Enallagma exsulans			x	x							x		

Table C-8 (cont.)

Organisms	Occurrence												
	River			Cedar			Brushy			Holland			Other Tributaries
	U	M	L	U	M	L	U	M	L	U	M	L	
E. basidens			x	x							x		
E. divagans													x
E. signatus													x
E. civile		x	x	x			x				x		
Anomalagrion hastatum	x	x	x	x			x	x					x
Plecoptera													
Perlesta placida					x								x
Isoperla sp.									x				x
Taeniopteryx titia			x										
Hemiptera													
Notonectidae													
Notonecta sp.													x
Buenoa sp.													x
Hydrometridae													
Hydrometra sp.	x												
Belostomatidae													
Benacus griseus			x										
Belostoma													x
Abedus		x	x										
Pleidae													
Plea striola	x												
Nepidae													
Ranatra sp.	x												x
Corixidae													
Trichocorixa calva			x			x							
T. kanza						x							
T. louisianae						x							
Palmacorixa buenoi						x							
Corbella edullus						x							
Graptocorixa sp.													x
Hebridae													
Merragata sp.						x							
M. hebroides						x							
Hebrus consolidus						x							
Gerridae													
Gerris		x	x										x
Rheumatobaetes sp.	x												x
R. tenuipes						x							
R. rileyi						x							
R. hungerfordi						x							

Table C-8 (cont.)

Organisms	Occurrence													
	River			Cedar			Brushy			Holland			Other Tributaries
	U	M	L	U	M	L	U	M	L	U	M	L	
Trepobates subnitidus	x		x										x
Limnogonus sp.	x												
Gelastocoridae													
Gelastocoris oculatus oculatus						x							
Mesoveliidae													
Mesovelia amoena						x							
M. mulsanti						x							
Neuroptera													
Sialis sp.				x	x	x		x			x	x	
Megaloptera													
Corydalus cornutus		x	x		x	x							x
Chauliodes sp.		x											x
Coleoptera													
Dytiscidae													
Agabates sp.			x										
Laccophilus proximus	x			x			x	x	x		x		x
Laccodytes sp.			x		x		x	x	x		x	x	
Bidessus sp.								x					
Hydroporus dimidicatus		x	x	x									
Derovatellus sp.			x										
Copelatus sp.			x										
C. chevrolati				x			x						
Comptotomus sp.		x	x			x							x
Ababus													x
Oreodytes sp.								x					
Laccornus sp.			x										
Thermonectus ornaticolis													x
Hydrocanthus sp.				x									
Hydrophilidae													
Tropisternus sp.				x					x				
T. mexicanus						x							x
T. lateralus nimbatus	x						x	x					x
Berosus peregrinus	x			x			x	x	x				
B. infuscatus	x	x					x				x		x
Helophorus sp.					x					x			
Hydrochus sp.	x		x	x			x	x	x		x		
Paracymus sp.	x			x							x		

Table C-8 (cont.)

Organisms	Occurrence												
	River			Cedar			Brushy			Holland			Other Tributaries
	U	M	L	U	M	L	U	M	L	U	M	L	
Anacaena										x			
Helochares sp.				x				x					
H. maculicollis							x			x			
Cymbiodyta sp.										x			
Hydrochara sp.													x
Hydrophilus sp.							x	x					
Enochrus spp.				x			x						
E. pygaeus						x							
Laccobius sp.				x									
Hydrobius sp.				x									
Gyrinidae													
Dineutes sp.	x	x	x			x	x						x
Gyrinus sp.						x			x				
Gyretes sp.	x					x			x				
Elmidae													
Stenelmis sp.			x	x		x							x
Dubiraphia sp.						x							
Halipilidae													
Peltodytes spp.			x	x		x	x	x			x		x
Haliplus spp.		x	x				x				x		
H. triopsis				x									x
Dryopidae													
Helichus sp.				x	x								
Noteridae													
Hydroconthus sp.				x									
Chrysomelidae													
Donacio sp.													x
Helodidae													
Scirtus													x
Cyphon sp.													x
Omphoronidae													
Omophoron nitidum													x
Trichoptera													
Hydropsyche sp.				x		x					x		
Cheumatopsyche spp.				x	x	x				x	x		
Polycentropus sp.				x	x								
Neureclipsis sp.					x								
Mystacides sp.			x										
Leptocella sp.							x						
Triaenodes sp.						x							
Agraylea sp.										x			
Tascobia sp.						x							

Table C-8 (cont.)

Organisms	Occurrence												
	River			Cedar			Brushy			Holland			Other Tributaries
	U	M	L	U	M	L	U	M	L	U	M	L	
Diptera													
Tendipedidae (Chironomidae)													
Pentaneura sp.	x	x	x	x	x	x	x	x	x	x	x		
Tendipes spp.		x		x	x	x		x	x		x		
Procladius skuse				x									
Coelotanypus sp.					x								
Polypedilum spp.					x								
Prodiamesa sp.					x								
Cardiocladius sp.					x								
Anatopynia sp.					x								
Sphaeromias sp.					x								
Hydrobaenus sp.					x								
Lauterborniella sp.					x								
Tanytarsus spp.					x								
Calospectra sp.					x								
Ceratopogonidae													
Dasyhelca					x								
Culicoides spp.					x								
Alluaudomyia sp.					x								
Palpomyia sp.					x								
Simuliidae					x								
Culicidae													
Culex sp.		x						x			x		
Chaoborus sp.		x						x					
Anopheles sp.					x								
Stratiomyiidae													
Stratiomys sp.								x	x		x		
Nemotelus sp.											x		
Tabanidae													
Tabanus sp.					x						x		x
Chrysops sp.					x								
Tipulidae													
Erioptera sp.		x						x					
Mollusca													
Gastropoda													
Physa virgata = *Physa anatina*	x	x	x	x	x			x	x	x	x	x	x
Lymnaea sp.			x								x	x	
Gyraulus sp.			x					x					
Helisoma sp.													x

Table C-8 (cont.)

Organisms	Occurrence												
	River			Cedar			Brushy			Holland			Other
	U	M	L	U	M	L	U	M	L	U	M	L	Tributaries
H. trivolvis lentum	x												x
Ferrissia sp.				x									
Helicina arbiculata		x											
Polygyra sp.	x												
Pelecypoda													
Carnunculina texasensis	x	x		x	x		x	x	x		x		
C. parva					x								x
Tritogonia verrucosa		x											
Fusconaia sp.		x											
Amblema costata = *A. perplicata*		x			x								
Elliptio sp.		x											
Anodonta imbecilis													x
Sphaerium striatinum	x	x	x	x	x		x	x	x				x

D-1. Archeological Elements. The Upper Navasota Dam and Reservoir (Lake Limestone) will affect portions of Leon, Limestone, and Robertson counties in east central Texas. The project area is located in the western edge of the east Texas timber belt: soils are claypan Alfisols of the Lufkin-Axtell-Taber associations (Godfrey et al., 1973) Soils within the present flood plain are of the Navasota series.

The affected area was surveyed to a projected level of 370 feet to insure full coverage of the reservoir margins. Additional data as reported by local collectors in adjacent areas was recorded to provide comparisons to data and artifacts collected within the confines of the project itself.

With a few exceptions, the sites in the survey area are contained within a thin sandy matrix up to one foot thick overlying clays of Eocene Age. The exceptions include those sites which are contained in sands significantly deeper than one foot. Many of the sites are now in cultivated or pasture lands which were formerly wooded. These have been cleared of timber within recent years with the aid of bulldozers; this, in itself, constitutes an inherent threat to the integrity of archeological deposits by churning the surface layers. This effect is compounded in this area especially by virtue of the shallow, fragile nature of the artifact-bearing deposits. Burrowing animals have also contributed to the mixing of layers. The occasional pothunter, superficially, appears to have caused little damage.

As a consequence of these combined activities, it can be postulated that the vertical separation of artifacts accumulated through time at any given shallow site within the reservoir area has been obscured to the point that visible separation is not possible. However, that does not mean the sites are no longer of potential value. Gross trends of vertical distribution and horizontal clusterings of various artifacts can yield information of significance in determining resource use or activity specific areas such as chipping localities and cooking areas. Time diagnostic artifacts may be compared with adjacent areas to reveal the general age ranges.

D-2. Archeological Evidence. As a result of Prewitt's survey 52 archeological sites were recorded within or around the margins of the proposed reservoir. Four sites had been previously recorded near the upper end of the reservoir, and an additional eight sites are known in the area. Of more than 60 archeological sites in the affected area, 16 were deemed worthy of further investigation (Prewitt, 1974) (41 LN 20, 21, 25; 41 LT 12, 14, 17, 26, 30, 31, 32, 33, 34, 35, 42, 44; 41 RT 2.)

Of these, the Barkley site (41 LN 20) and the Louie Sadler site (41 RT 2) were tested to any real extent. Both sites appear

to be just above the normal flood levels, on erosional remnants along either side of the Navasota River, but, according to local informants, they are subject to partial inundation by the occasional short-term flood. Both yielded evidence of extensive prehistoric utilization.

Although much important information was obtained from these excavations (Prewitt, 1975) the data from these two sites alone are too meager to allow complete or accurate definition of the adaptive strategies of the Paleo-Indian inhabitants. Nor can we determine specific forms of influence, pressures or other interactions worth adjacent groups.

The sites are fairly evenly distributed along the mainstem valley of the river with the large majority being located on the crests or slopes of the eroded margins of the valley. Frequent overbank flooding and the occasional inundation of the flood plain, evidenced in the much seen channel scars, have contributed to rendering the plain unsuitable for row crop farming and permanent habitation.

D-3. Impacts on Archeological Elements. Because of this project, funds were made available by the Brazos River Authority for a systematic survey of archeological resources in the area. Additional funding will be provided for the excavation of the sites deemed most important (BRA, 1976). The remainder of the sites within and around the margins of the reservoir will suffer varying degrees of direct and indirect effects. Observation of sites of similar nature (e.g., shallow and sand caps overlying clay) in other reservoir areas has demonstrated the potential dangers which inundation and fluctuation of shorelines pose to archeological materials. Witty (1973) observed severe directional scour and deflation of totally inundated sites, and Prewitt and Lawson (1972) observed severe lateral erosion and deflation at sites subjected to shoreline situations.

There is no doubt that the sites in Lake Limeston will be similarly affected. The inherent nature of the principal use of the lake will contribute to directional scour of sites on the flood plain and fluctuating shoreline erosion of sites along the valley margins. Indirect (or defferred) effects will probably result from the anticipated secondary use of the reservoir as a recreation area. Wave action generated from fishing and pleasure boats should aggravate shoreline erosion, and relic hunters will undoubtedly be attracted to those sites exposed along the shoreline. These people destroy archeological sites through indiscriminate digging for the sake of aesthetially pleasing artifacts which they trade, sell, or proudly display on their mantle pieces. The results of such "pothunting" contributes little toward the understanding of prehistoric peoples other than the fact that many of them were true artisans in the manufacture of certain artifacts.

D-4. Recommendations. The recommendations summarized in table D-1 have been formulated on the following basis:

(1) Representative sampling of types of sites, e.g. flood plain and valley margin sites, deep and shallow sites, and Archaic and Post-Archaic sites; and

(2) Potential data yield as indicated by surface collections and minor sub-surface probes.

A total of 16 of the 52 sites recorded during the survey were recommended for further excavations. On two sites extensive testing was later accomplished. The following approach is suggested for recovering the maximum amount of information with a minimum amount of time and money expended:

(1) Conduct test excavations at all 16 of the sites recommended for further work; then

(2) Select the most informative of these sites for more intensive investigations.

It is anticipated that no more than three months will be necessary for the field work to test the 16 sites (Prewitt, 1974). Testing is herein defined as controlled hand excavations assisted by machine excavations (backhoe) where necessary, compilation of a plane table or transit map of the site, and verbal and graphic recording of the information recovered. The time necessary for more intensive investigations should be determined after the testing program is completed and should be based on the predicted amount of work needed at those sites deemed worthy of more extensive excavations.

D-5. Conclusions. An archeological survey of the proposed Lake Limestone in east-central Texas has yielded evidence of 52 prehistoric sites and historic sites. Conflict of the proposed reservoir with the historic resources appears to be minimal; however, there is significant conflict with documented archeological resources. Analysis of the sites has shown that they are fragile in nature and that they will suffer irreversible adverse effects from both direct and indirect consequences of dam construction and impoundment of the reservoir.

Analysis of the artifacts indicates that the area was inhabited by prehistoric peoples over a relatively long period of time -- from early Archaic through Post-Archaic times. No radiometric dates are available from the immediate area to lend specific estimates of the time of these occupations. Stylistic variations within the artifacts suggests that people in the area experienced influences of varied intensity from adjacent cultures in East Texas and Central Texas while the geographical locations of the sites suggest a reasonably stable resource base.

TABLE D-1

Summary of Archeological Recommendations

Further Excavations	No Further Work		
LN 20 * @	LN 22**	LT 29	RT 3
LN 21 *	LN 23 *	LT 36	RT 4
LN 25	LN 24	LT 37	RT 5
		LT 38	RT 6*
LT 12	LT 13	LT 39	RT 7
LT 14	LT 15	LT 40	
LT 17	LT 16	LT 41	
LT 26	LT 18	LT 43	
LT 30	LT 19	LT 45	
LT 31	LT 20	LT 46	
LT 32	LT 21	LT 47	
LT 33	LT 22	LT 48	
LT 34	LT 23	LT 49	
LT 35	LT 24	LT 50	
LT 42	LT 25	LT 51	
LT 44	LT 27		
	LT 28		
RT 2* @			
Totals:			
16 Sites			36 Sites

* Discussed in recommendations of Letter Report, August 1, 1975.

** If this site cannot be avoided by construction activities, test excavations should be conducted as stated in Letter Report, August 1, 1974.

@ Two archeological sites within the construction area of the proposed Upper Navasota Dam were tested by the Texas Archeological Survey during February and March of 1975. The sites, the Barkley Site (41 LN 20) and the Louie Sadler Site (41 RT 2), yielded evidence of extensive prehistoric utilization. Area A at the Barkley Site contained materials relatable to late Paleo-Indian peoples as well as to the entire spectrum of Archaic age peoples whose remains conform to the description of the La Harpe Aspect. Area B at the Barkley Site and Area A at the Louis Sadler Site contained materials suggesting Post Archaic Occupation.

No significant vertical separation of the deposits or artifacts was discerned. Time depth is assumed on the basis of variations in artifact styles and their horizontal distributions. Comparisons with localities in similar geographic situations suggest the peoples in the Upper Navasota River and adjacent regions were subjected to cultural influences and pressures from peoples in adjacent regions.

It is concluded that the area encompassed by the project area contains potentially significant archeological information relative to understanding the interaction between prehistoric cultures which developed in adjacent areas. The aggregate of prehistoric sites recorded is deemed of sufficient significance for nomination to the National Register of Historic Places, and merits further investigation. The recorded historical resources are not considered worthy of further study. A letter from Gary L. Hume, Director of the National Register Programs for Texas stating that "...there are currently no sites listed in, or nominated to, the National Register of Historic Places within those portions of Leon, Limestone, and Robertson Counties." was received and is on file with the Texas Archeological Survey (Prewitt, 1974).

D-6. History of Robertson, Leon and Limestone Counties. The Navasota River, which rises in southern Hill County, flows southeast across Limestone County and forms the county line between Leon and Robertson Counties. The river probably was named by Indians who called it, or another stream in the vicinity, the Navasota (Texas State Historical Association, 1952).

Robertson County, named for Sterling C. Robertson, is situated on the divided between the Brazos and Navasota rivers. The county was created from Milam County in 1837 and organized in 1838. The Texas State Historical Association (1952) compiled the following historical aspects of Robertson County:

> The area now in Robertson County was occupied by Tawakoni, Kichai, Waco, Caddo, Anadarko, Delaware, and Cherokee Indians before the arrival of white settlers. Domingo Teran de los Rios probably crossed the county on his way to Northeast Texas in 1690, and it lay on the path that Domingo Ramon traversed as he progressed across Texas to found Spanish missions in East Texas in 1716. When W. B. Dewees explored the area in 1822, he found herds of buffalo, wild cattle, horses, and peccaries. In 1825 the area of present Robertson County was included in the bounds of the Robertson Colony. When Felix Robertson and Sterling C. Robertson went to the area in 1826, a settler named Early was already in possession of a piece of land included in the grant, and the alcalde of the region, John P. Coles, was unable to remove him. Benjamin F. Foster and others began a settlement in 1826 but were interrupted by the outbreak of the Fredonian Rebellion. The Law of April 6, 1830, suspended operation of the colonists' contract for almost four years, and quarrels which developed also slowed settlement which actually began in 1834 with the building of Jared Groce's fort at a location later called Old Cobb Prairie. Marysville, on the west side of the Brazos below Viesca, was also established in 1834.

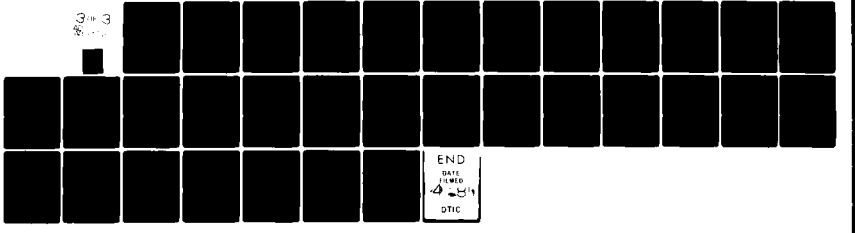
When the county was organized in 1850, Old Franklin was headquarters for surveyors of a land district including present Leon, Freestone, Limestone, Navarro, and other counties and became the county seat. In 1846 the present limits of the county were created, and the shift in the center of population caused the move of the county seat to Wheelock in 1867. A new courthouse was erected on land donated by Mary E. Wheelock, and Old Franklin became a ghost town. An election in 1854 ordered a new site of county government at a more convenient location. A spot at the head of Cedar Creek one and one-half miles southeast of the center of the county was rejected; then in 1855 a townsite was laid off on Walnut Creek and called Owensville for Harrison Owen, first county clerk, and accpeted as county seat. A change of site to Calvert in 1860 left Owensville to become a ghost town. Calvert retained the county seat after an election contested with Englewood in 1874, but in 1879 the seat of government was moved to Morgan on the new International-Great Northern Railroad. When application was made for a post office, Morgan was renamed Franklin in honor of the original county seat.

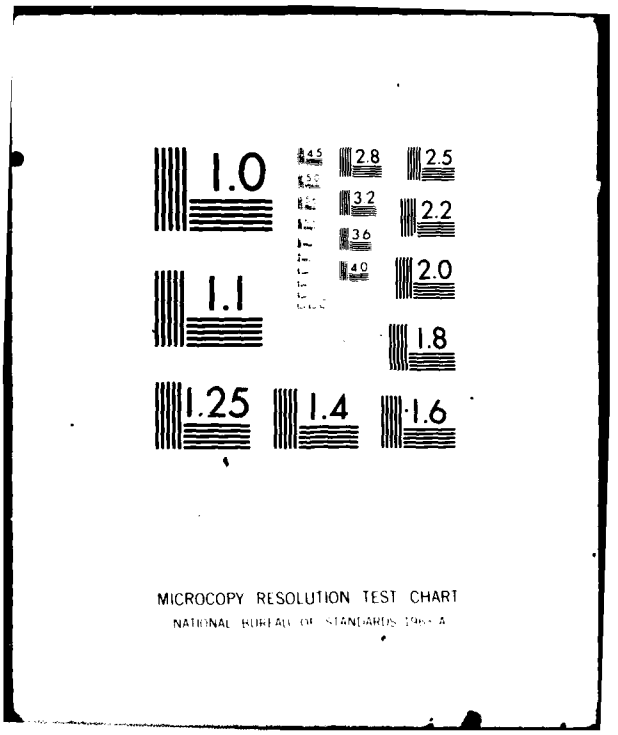
Plantation owners from the south found the river lands of the Robertson Colony grant suitable for cotton, which was the chief crop by 1834. Settlement in the western part of the county was delayed until the making of an Indian treaty in 1843; militia company beats with regular patrols continued to protect the county until the close of the Civil War. The first school in the county was Franklin Academy, established in 1838. The county had one church in 1840, a mission at Nashville, where a Methodist minister served twelve appointments. The first camp meeting in the county was held on Cedar Creek in 1841. By 1850, there were fifteen schools in the county. The Houston and Texas Central Railroad (later the Texas and New Orleans) reached Bremond in 1869, and the International-Great Northern made a junction with it at Hearne in 1880. By 1850 the county's population of 934 included 314 slaves; by 1870 population was 4,[illegible] and by 1880, 22,383, half of which were Negroes. The county's peak population was reached in 1900 with a figure of 31,4[illegible].

Limestone County, which takes its name from the native limestone, was created from Robertson County and organized in 1846. A synopsis of the County's history by the Texas State Historical Association follows:

AD-A097 021 ARMY ENGINEER DISTRICT FORT WORTH TEX F/G 13/2
STERLING C. ROBERTSON DAM AND LIMESTONE LAKE ON THE NAVASOTA RI--ETC(U)
APR 76

UNCLASSIFIED NL




1.0
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4.0
4.5
5.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

The region now in Limestone County lay north of the Old San Antonio Road so was not on the routes of many of the early Spanish explorers, but the Marquis de Aguayo traversed the area in 1720 as he marched to re-establish and strengthen the missions in the East Texas area. The section was occupied by Indian tribes when the Anglo-American settlers arrived in 1833, feuds between the Cherokee and the Waco and Tawakoni, who were concentrated in the area, making settlement hazardous. A colony led by James W. and Silas M. Parker, settled at Fort Parker on the Navasota in 1834. Commanche and Caddo attacked the fort in May, 1836, killing some members of the colony and capturing other, including Cynthia Ann Parker. In 1838 Indians attacked a party of surveyors on Battle Creek, and seventeen were killed.

The first post office in Limestone County was Alta Springs, established in 1846 with DeWitt C. Vary as postmaster. Mail was delivered to the area by Tilman Wolverton, who drove the stage from Brenham to Fairfield. The first school in the county was taught in 1846 by John Ward, who used a log house near the spring by Fort Parker. Organization of the county in 1846 made Springfield the county seat. County population was 1,856 in 1848 and increased to 2,608 in 1850, slaves numbering 618. Plantation farming and lumbering were the chief industries. By 1856 there were post offices at Springfield, Mount Vernon, and Tehuacana Springs. The first company raised in the county for Confederate Army was that of Lochlin Johnson Farrar: other companies were led by Captains D. M. Prendergast, B. R. Tyrus, and W. P. Brown. Three-fourths of Limestone County's voting strength served the Confederacy, and Reconstruction was particularly difficult in the area.

The Houston and Texas Central Railroad reached Limestone County in 1869 and built on from Kosse to Groesbeck in 1870. Springfield declined as the shipping points grew, and in 1873 an election moved the county seat to Groesbeck. Further railroad building included one mile across the northwest corner built by the St. Louis and Southwestern in the late 1880's and twenty-two miles built by the Trinity and Brazos Valley (the Burlington-Rock Island) in 1906. Gas was discovered in 1912 and Mexia boomed as an oil center in the 1920's.

Leon County is bounded on the east by the Trinity River, on the west by the Navasota River, and on the south by the Old San Antonio Road. County history dates back to the early Spanish explorers as is pointed out by the Texas State Historical Association (1952):

In 1691 Domingo Teran de los Rios traversed the county on his way to inspect Spanish claims in East Texas. In 1718 Martin de Alarcon crossed the southeast tip of the present county. Peter Samuel Davenport, in 1809, reported the principal village of the Quitseys (Kichai), with sixty warriors and their families, to be located six leagues west of the Trinity and ten leagues above the Old San Antonio Road in the vicinity of present Leona. The first Anglo-American settlers found the Kichai living two and a half miles north of the present site of Centerville, the Indians being expelled by Robert M. Coleman in 1835. The Kickapoo who lived on the west bank of the Trinity, were expelled with the Cherokee in 1839.

Leon County, part of the Stephen F. Austin and Samuel M. Williams colonial grant was created from Robertson County in 1846 and named for a yellow wolf of the region called the leon (Other authorities say that the county was named for the empresario, Martin de Leon.) In 1840-1841 the earliest settlers built a blockhouse called Fort Boggey in the region later known as Rogers Prairie. With the organization of the county in 1846 Leona was made the county seat. About 1847 the population was distributed along the Trinity at steamer landings such as Cairo, Commerce, and Brookfield's Bluff, later ghost towns. The county seat was moved to Centerville in 1851. In 1870 the population was 6,523. In 1872 the International-Great Northern Railroad built from west to northeast across the county. About 1907 the Trinity and Brazos Valley, later the Burlington-Rock Island, made a junction with the earlier road at Jewett. By 1910 population was 16,583.

First schools in the county were located at Rocky Ridge and Leona. In 1882 the public school system was organized. The Leon Pioneer was published by W. D. Wood in Centerville in 1851. The Democratic Farmer was established in 1883 and was followed by the Centerville Democrat in 1885.

In 1947 Leon County was chiefly interested in lumbering and hog producton. Hunting and fishing attracted tourists to the area and to Normangee State Park in the southwest corner of the county.

D-7. Historical Sites. The records of the Texas Historical Commission indicate that there are 76 historical sites located within the three-county area (SwRI, 1975). Of these, the Hammond House in the city of Calvert, Robertson County, is the only site that is listed with the National Register of Historic places in the Federal Register, February 4, 1975. Table D-2 lists the historic sites which exist within the proximity of the project area. However, no known sites of historical value will be affected by the construction of the project (SwRI, 1975).

TABLE D-2
HISTORICAL SITES

Category	Historic Site Title	Location	City	County
3	Fort Parker	3 miles north on SH 14	Groesbeck	Limestone
3	Fort Parker Memorial Park-Cemetery	1.5 miles north on SH 14	Groesbeck	Limestone
3	L. L. Foster	Courthouse Lawn	Groesbeck	Limestone
3	Lost Prairie Cemetery & Church	10 miles NW off SH 164	Groesbeck	Limestone
3	Mrs. C. D. Kelly-Fort Parker Memorial Park Cemetery	1.5 miles north SH 14	Groesbeck	Limestone
3	Old Personville	9 miles east on FM 39	Groesbeck	Limestone
3	Old Springfield Cemetery, Fort Parker State Park	3 miles north on Park Road 28	Groesbeck	Limestone
5	Abram Anglin-Faulkenbert Cemetery	2 miles north	Groesbeck	Limestone
5	Allen Jefferson Rogers-Lost Prairie Cemetery	11 miles east on SH 164	Groesbeck	Limestone
5	Azariah G. Moore-Lost Prairie Cemetery	11 miles east on SH 164	Groesbeck	Limestone
5	John Sadler-Ferguson Cemetery	16.5 miles southwest on SH 14	Groesbeck	Limestone
5	John Penn Lynch-Springfield Cemetery, Fort Parker State Park	3 miles north on SH 14	Groesbeck	Limestone
5	Sanders Walker-Springfield Cemetery, Fort Parker State Park	3 miles north on SH 14	Groesbeck	Limestone
5	Seth H. Bates-Fort Parker Cemetery	1.5 miles north on SH 14	Groesbeck	Limestone
5	Sion Roberts-Dooley Family Cemetery	10 miles southwest on FM 937, 2.2 miles on dirt road	Groesbeck	Limestone
3	Old Moss Home	3 miles east on SH 7	Kosse	Limestone
5	Charles Q. Haley	Kosse Cemetery	Kosse	Limestone
3	The Potter Shop	12 miles east on FM 1246	Thornton	Limestone
5	James Alfred Head-Small Cemetery	4 miles north on SH 7	Bald Prairie	Robertson
3	St. Mary's Catholic Church	800 North Main	Bremond	Robertson
3	Wootan Wells	FM 1373, 3.5 miles west	Bremond	Robertson
3	Calvert	600 Main Street	Calvert	Robertson
3	Calvert Courthouse (Hammond House)	600 Pine Street	Calvert	Robertson
3	Chinese Farmers	Highway Access Road	Calvert	Robertson
3	Church of the Epiphany	Corner of Gregg and Elm Streets	Calvert	Robertson
3	Citizens Bank and Trust	Main Street	Calvert	Robertson

TABLE D-2 (Continued)

Category	Historic Site Title	Location	City	County
3	Cobb's Market	517 Main Street	Calvert	Robertson
3	First Presbyterian Church	401 North Barton Avenue	Calvert	Robertson
3	Old Calvert Foundry and Manufacturing Company	502 Main Street	Calvert	Robertson
3	Randolph	Field House	Calvert	Robertson
3	Rev. Joseph P. Sneed	10 miles east	Calvert	Robertson
3	Virginia Field Park	809 Mitchell	Calvert	Robertson
5	Captain Henry Reed	6 miles east on FM 979	Calvert	Robertson
6	Hammond House	Bounded by Burnet, China Elm and Hanna Streets	Calvert	Robertson
1	Robertson County	1.3 miles east on US 79	Franklin	Robertson
3	General Walter W. Williams, Mt. Pleasant Cemetery	4 miles east on FM 2446	Franklin	Robertson
3	Sheriff Bob Reeves	Franklin Cemetery	Franklin	Robertson
3	Robertson County Courthouse	Courthouse Square	Franklin	Robertson
2	Colonel Robert S. Gould	4 miles south on US 79	Buffalo	Leon
1	Site of Fort Boggy	5 miles south off US 75	Centerville	Leon
3	Leon County Courthouse	Courthouse Square	Centerville	Leon
5	R. Baxter King-King Family Cemetery	12 miles south on FM 1119	Centerville	Leon
3	Bowling Community Lodge	6 miles southeast on FM 1147	Marquez	Leon

KEY TO CATEGORIES

Category 1 - 1936 Texas Centennial Markers and Texas War for Independence Markers erected by the State.
Category 2 - Civil War Markers, erected by the State especially for the Civil War Centennial, 1961-1965.
Category 3 - Texas Historical Markers and Building Medallions (without plates); also granite historical markers erected by the State.
Category 4 - Private, State-approved markers.
Category 5 - 1936 Texas Centennial Grave Markers and Texas War for Independence Grave Markers.
Category 6 - National Register of Historic Places.

SOURCE: Texas State Historical Survey Committee (1971).

E-1. Land Use. The land use in the three counties, Leon, Limestone, and Robertson, is predominantly agricultural with 73.6 percent, 80.8 percent and 75.2 percent of their respective acreages in farms (U.S. Bureau of the Census, 1973). Table E-1 indicates the general land uses for the three-county area. Urban, as used here, is defined as a community of more than 2,500 persons.

TABLE E-1. LAND USE IN THE THREE-COUNTY AREA

Category	Percentages		
	Leon	Limestone	Robertson
Urban and Built up	1.44	3.1	1.95
Water	0.20	0.9	0.64
Cropland	8.69	23.3	23.38
Pasture/Rangeland	47.83	55.9	46.28
Forest	41.53	16.3	26.66
Other Land	0.31	0.6	1.09
Total Acreage	705,012	595,520	561,152

Source: Brazos Valley Development Council (1975) and Heart of Texas Council of Governments (1974).

Leon County does not contain any communities that qualify under this definition of urban. The largest community in Leon County is Buffalo, having a population of 1,242 in 1970.

Ranching exceeds all other agricultural land uses in the three-county area with livestock, in the form of beef cattle, accounting for most of the agricultural effort. According to SwRI (1975): "Over 80 percent of Leon County's annual $10 million in farm income comes from livestock. Similarly, Limestone County receives 90 percent of its average farm income of $9.5 million from livestock, including poultry. Of Robertson County's average $13 million farm income, 75 percent is from beef cattle, hogs, and poultry."

Robertson County, using irrigation, produces the most truck crops of the three-county area, in addition to cotton and sorghum crops. Leon County's main crops include cotton, grains, melons, and peas. Cotton, grains, peaches, and pecans are the major crops to be found in Limestone County (SwRI, 1975).

Extensive sections within the three-county area are forested with tree vegetation including mesquite, hickory, and various oaks. However, these trees are not harvested for sale as lumber. Although some wood is undoubtedly being cut and sold for firewood, this activity is not significant enough to be reported in any detail (SwRI, 1975).

Mining activity in the area is limited to the production of clay, sand, and gravel. Although some good quality pottery clay, kaolin, exists in southern Limestone County, the clay is no longer being mined for pottery. However, some brick plants do operate in the area, and these plants utilize clay in their operation. Other mineral interests in the area include oil and gas (SwRI, 1975).

Future land use patterns in the three-county area are expected to follow past trends, i.e., crop lands will continue to be converted to pasture and rangelands as will some forest lands. Construction of Robertson Dam and the resulting Limestone Lake would drastically change the land use of the 14,200 acres directly involved in this project as well as the area immediately surrounding the project. Conversion of rural lands into developments similar to those found surrounding other lakes as Cedar Creek and Livingston would be expected unless prevented by local entities.

E-2. Demographic Characteristics. Selected demographic characteristics of the three-county area are shown in the table E-2.

TABLE E-2. DEMOGRAPHIC CHARACTERISTICS

Characteristics	Counties			State of Texas
	Leon	Limestone	Robertson	
1970 population	8,738	18,100	14,406	11,195,431
Female population (percent)	52.2	55.3	52.2	51.1
Density (persons/sq mi)	8	19	16	43
Urban Population (percent)	0.0	32.7	36.0	79.8
Rural farm population (percent)	16.8	7.3	12.6	3.4
Rural non-farm population (percent)	83.2	60.0	51.4	16.8
Birth rate (per 1000 pop.)	9.7	11.0	17.1	19.3
Death rate (per 1000 pop.)	16.1	14.4	15.4	8.5
Median age (years)	41.2	40.4	35.7	26.6

Source: U.S. Bureau of the Census (1973).

Leon County is relatively unique in that it contains no urban population, i.e., communities of more than 2500 persons. The rural population, comprised mostly of non-farm residents, is significantly higher in percentage than the rural population of the state. The high median ages of the three counties corresponds to their relatively low birth rates and high death rates.

E-3. Population Characteristics. As in many rural counties of Texas, the populations of Leon, Limestone, and Robertson Counties are declining. The projected populations for the three-county area are shown in table E-3.

TABLE E-3. POPULATION PROJECTIONS 1960-1995

County	1960	1970	1975	1980	1985	1990	1995
Leon	9,951	8,733	8,219	7,814	7,516	7,344	7,241
Limeston	20,413	18,100	17,180	16,264	15,279	14,265	13,345
Robertson	16,157	14,389	14,112	13,847	13,584	13,342	13,096

Source: Heart of Texas Councile of Governments, (1974); Brazos Valley Development Council (1975).

Limestone County is expected to experience the greatest loss of people, both numerically and percentage-wise, in the 25-year period of 1970-1995. These rural area losses are attributed mainly to the continued migration of younger wage earners to the metropolitan areas where more job opportunities exist. The age composition of the three-county area's population is given in the table E-4.

TABLE E-4. AGE COMPOSITION
(In percentages)

Category	Counties			State of Texas
	Leon	Limestone	Robertson	
Under 5	6.1	5.0	8.0	8.9
5 to 14	18.9	15.6	19.8	20.9
15 to 24	12.5	14.7	13.9	18.4
25 to 34	7.4	9.5	7.8	12.6
35 to 44	8.6	9.7	8.5	11.6
45 to 54	11.5	11.3	10.9	10.6
55 to 64	15.1	14.2	12.8	8.6
65 and older	19.8	20.1	18.3	9.0

Source: U.S. Bureau of the Census (1972).

The relatively low percentages in the 25-44 age category substantiates the statement regarding the migration of this age group to some other area for employment. The birth rate (table E-2) for the three-county area is significantly below that for the state. The combined low birth rate and relatively low percentage of persons in the 25-44 age bracket have significantly increased the median age category for this area over the median age for the state.

The Lake Limestone project, together with the two steam electric power generating facilities to be constructed in the area, will reduce the emigration of younger wage earners and their families and will assist in lowering the median age for the three-county area.

E-4. Racial and Ethnic Characteristics. The total population of the three-county area in 1970 was 41,244 with a racial composition of 70.1 percent whites and 29.9 percent blacks. The Spanish-American ethnic group, counted primarily in the white race, but includes some blacks and other races, accounted for 3.8 percent of the population (U.S. Department of Labor, 1975). The population composition of the three-county area is shown in table E-5.

TABLE E-5. RACIAL AND ETHNIC CHARACTERISTICS-1970

	Leon	Limestone	Robertson	3-County Area
Total population	8,738	18,100	14,389	41,227
Black population	2,723	4,499	5,114	12,336
Percent Black	31.2	24.9	35.5	29.9
Spanish American	80	249	1,249	1,578
Percent Spanish American	0.9	1.4	8.7	3.8

Source: U.S. Bureau of the Census (1972).

E-5. Educational Attainment. Of the total population 25 years old or older in the 3-county area 69.9 percent had less than a high school education, and 5.4 percent were college graduates. Table E-6 contains a county by county educational profile of the area.

TABLE E-6. EDUCATION 1970

Persons 25 years old and older	County			State of Texas
	Leon	Limestone	Robertson	
Total	5,498	11,717	8,370	5,817,155
Median (years)	10.1	9.8	9.3	11.6
Less than 5 years (Percent)	10.7	17.3	15.5	9.3
4 yrs of high school or more (%)	31.5	30.0	29.2	47.4
4 yrs of college or more (%)	6.1	5.0	5.4	10.9

Source: U.S. Bureau of the Census (1973).

The difference in the educational achievements of the state as a whole and the three counties can partially be attributed to the migration of rural populations toward greater job opportunities in urban areas. Mobility is increased by education, and this results with those citizens having the least education remaining in the rural areas where limited occupational opportunities exist.

E-6. Economic Characteristics. The general employment by major industry is shown for the three counties and the state in table E-7. As expected, employment in the agriculture, forestry and fisheries

TABLE E-7. 1970 EMPLOYMENT BY INDUSTRY

Industry	COUNTY								State of Texas
	LEON		LIMESTONE			ROBERTSON			
	Rural	Percent	Rural	Urban	Percent	Rural	Urban	Percent	Percent
Agriculture, Forestry & Fisheries	392	14.7	434	30	8.2	618	75	16.0	4.2
Construction	317	11.9	288	72	6.3	265	86	8.1	7.0
Manufacturing	202	7.6	409	132	9.5	233	130	8.3	17.3
Transportation, Communication & Other Public Utilities	169	6.4	175	61	4.1	241	32	6.3	6.5
Wholesale & Retail Trade	513	19.3	629	375	17.7	493	222	16.4	20.7
Personal Services	260	9.8	205	600	14.2	253	237	11.3	5.3
Professional & Related Services	405	15.2	987	257	21.9	438	143	13.4	15.6
Other Industries	403	15.1	400	631	18.1	266	610	20.2	23.4
Sub Totals	2,661	100.	3,527	2,158	100.	2,807	1,535	100.	100.
Total Employed, 16 yrs old & over	2,661	100.	5,685		100.	4,342		100.	4,141,529

Source: U.S. Bureau of the Census (1972).

industry is significantly higher than that for the state. Also, manufacturing employment is much lower than that for the state as a whole. High personal services employment percentages for the number of persons employed in private households. The limited range of occupational opportunities and the lack of mobility in this rural setting has increased employment in private household positions. Table E-8 contains the employment projections to the year 2000 in agriculture, industry, commerce, and total employment, and indicates a rapidly diminishing labor force comparable to the declining population rate.

TABLE E-8. EMPLOYMENT PROJECTIONS

Agriculture Employment Projections

County					
Leon	1,044	392	296	212	151
Limestone	1,419	468	360	263	191
Robertson	1,663	696	547	410	306
Texas	301,261	194,635	185,543	172,107	158,832

Industry Employment Projections

Leon	647	732	624	515	436
Limestone	1,690	1,553	1,388	1,210	1,071
Robertson	1,047	1,353	1,188	1,019	898
Texas	1,187,949	1,472,147	1,747,029	2,046,714	2,376,138

Commerce Employment Projections

Leon	1,176	1,349	1,170	984	852
Limestone	3,226	3,407	3,030	2,613	2,308
Robertson	1,981	2,179	1,963	1,726	1,563
Texas	1,659,531	2,248,974	2,721,186	3,251,548	3,999,779

Employment Projections

Leon	2,978	2,661	2,258	1,856	1,568
Limestone	6,502	5,685	5,012	4,293	3,757
Robertson	4,834	4,342	3,804	3,251	2,856
Texas	3,318,503	4,141,529	4,939,240	5,824,580	7,077,004

Source: Brazos River Authority (1974).

The construction of the Robertson Dam, and resulting Lake Limestone, together with the Twin Oak and Oak Knoll steam electric power generating facilities, will offset some of the employment and population losses. It is projected that 10 permanent employees will be required by the Brazos River Authority and approximately 600 employees for power plants, lignite operations and other support industries (BRA, 1974).

E-7. Occupations. Table E-9, listing the major occupation groupings in the three-county area, shows that the state of Texas is higher in professional, technical and kindred workers, sales, and clerical jobs than the counties of Leon, Limestone and Robertson. However, the three-county area is higher than the state in farmers and farm managers, and farm laborers and farm foremen. The relatively large percentage of private household workers in the three counties is about two and one-half times that of the state.

TABLE E-9. OCCUPATION BY CATEGORY
(PERCENT)

Category	Counties			State of Texas
	Leon	Limestone	Robertson	
Professional, Technical and Kindred Workers	11.0	9.9	10.9	14.4
Managers and Administrators Except Farm	9.0	8.7	8.3	8.9
Sales Workers	3.3	5.9	5.0	7.8
Clerical and Kindred Workers	9.8	12.5	10.0	17.4
Craftsmen, Foremen and Kindred Workers	14.2	11.4	14.4	14.3
Operatives, Except Transport	7.9	10.4	10.1	11.1
Transport Equipment Operatives	3.9	3.5	3.2	4.0
Laborers, Except Farm	8.2	4.2	8.4	4.9
Farmers and Farm Managers	6.8	3.8	5.9	2.0
Farm Laborers and Farm Foremen	7.7	4.1	9.6	2.0
Service Workers, Except Private Household	12.6	20.4	8.2	11.1
Private Household Workers	5.6	5.2	6.0	2.2

Source: U.S. Bureau of the Census (1972).

E-8. Unemployment. The unemployment rates for the three counties are shown in table E-10. The unemployment rates for Leon and Robertson counties have increased at a much faster rate than the state. Limestone County, which percentage-wise has less agricultural employment, was significantly below the state unemployment rate in April 1975.

TABLES E-10. APRIL UNEMPLOYMENT RATES
(Percent)

	1970	1972	1974	1975
Leon County	2.0	2.8	4.8	7.8
Limestone County	3.1	6.4	3.8	4.6
Robertson County	2.8	3.4	4.0	8.2
State of Texas	3.6*	3.6*	3.8	5.9

*Annual Average

Source: Texas Employment Commission, Austin, Texas.

E-9. County Business Patterns. The business patterns of Leon, Limestone and Robertson Counties are shown in tables E-11, E-12, and E-13. The majority of the businesses in the three-county area are small, with about 80 percent of the reporting units employing seven or fewer persons.

E-10. Income Distribution. The income distribution for the three-county area is shown in table E-14. The three counties have a larger percentage of families with an income level up to $6000 than the established state average; however, those levels above $9000 are less. Therefore the area has more people in the low income bracket than the state average. All the median and mean incomes are significantly less than the state median and mean incomes for the different catgeories; in fact, many are as little as half that of the state (SwRI, 1975).

TABLE E-14. INCOME DISTRIBUTION

Income of Families and Unrelated Individuals	Percentages			
	Counties			State of
	Leon	Limestone	Robertson	Texas
Less than $3000	32.0	28.0	35.9	13.0
$3000 to $5,999	27.6	25.2	25.6	19.2
$6000 to $9999	22.3	26.0	23.1	27.8
$10,000 to $14,999	11.5	13.9	10.9	23.5
$15,000 or more	6.5	7.1	4.5	16.5
Median Income	$5131	$5619	$4562	$8490
Families less than Poverty Level in percent of all Families	30.2	19.8	36.1	14.6

Source: US Bureau of the Census (1972).

TABLE E-11. LEON COUNTY BUSINESS PATTERNS 1973[1]

	Number of Employees, mid-March Pay period	Taxable Payrolls, Jan-Mar. ($1,000)	Total Reporting Units	No. of Reporting Units by Emoloyment-size Class					
				1 to 3	4 to 7	8 to 19	20 to 49	50 to 99	100 to 249
Agricultural Services Forestry & Fisheries	D	D	2	-	2	-	-	-	-
Mining	D	D	4	2	1	-	1	-	-
Contract Construction	74	84	13	6	5	1	1	-	-
Manufacturing	D	D	4	1	2	-	-	-	1
Transportation & Other Public Utilities	10	18	3	2	1	-	-	-	-
Wholesale Trade	59	45	6	4	1	-	1	-	-
Retail Trade	314	250	76	47	19	9	1	-	-
Finance, Insurance & Real Estate	55	65	12	7	2	3	-	-	-
Services	164	138	24	17	2	2	3	-	-
Unclassified Est.	D	D	2	-	1	1	-	-	-
TOTAL	872	1,041	146	86	36	16	7	-	1

[1]Excludes government employees, railraod employees, self-employed persons, etc.
D=Denotes figures withheld to avoid disclosure of operations of individual reporting units.
Source: U. S. Bureau of the Census (1974).

TABLE E-12. LIMESTONE COUNTY BUSINESS PATTERNS: 1973[1]

	Number of Employees, mid-March Pay period	Taxable Payrolls, Jan-March. ($1,000)	Total Reporting Units	No. of Reporting Units by Employment-size Class					
				1 to 3	4 to 7	8 to 19	20 to 49	50 to 99	100 to 249
Agricultural Services Forestry & Fisheries	-	-	-	-	-	-	-	-	-
Mining	315	788	11	6	-	1	2	1	1
Contract Construction	65	55	23	14	8	1	-	-	-
Manufacturing	338	353	13	3	1	3	4	2	-
Transportation and Other Public Utilities	235	357	20	7	5	1	7	-	-
Wholesale Trade	115	132	20	13	5	-	2	-	-
Retail Trade	642	586	128	76	28	22	2	-	-
Finance, Insurance & Real Estate	147	208	31	20	4	6	1	-	-
Services	439	380	68	46	12	5	4	-	1
Unclassified Est.	8	5	4	4	-	-	-	-	-
TOTAL	2,304	2,864	318	189	63	39	22	3	2

1-Excludes government employees, railraod employees, self-employed persons, etc.

Soure: U.S. Bureau of the Census (1974).

TABLE E-13. ROBERTSON COUNTY BUSINESS PATTERNS: 1973[1]

	Number of Employees, mid-March Pay period	Taxable Payrolls, Jan-Mar. ($1,000)	Total Reporting Units	No of Reporting Units by Employment-size Class					
				1 to 3	4 to 7	8 to 19	20 to 49	50 to 99	100 to 249
Agricultural Services Forestry & Fisheries	11	9	3	2	1	-	-	-	-
Mining	-	-	-	-	-	-	-	-	-
Contract Construction	57	99	12	8	2	1	1	-	-
Manufacturing	677	1,130	11	2	-	2	2	2	3
Transportation and Other Public Utilities	156	290	15	6	4	1	4	-	-
Wholesale Trade	127	122	15	6	6	2	-	1	-
Retail Trade	457	413	103	63	22	17	1	-	-
Finance, Insurance & Real Estate	75	120	13	6	2	5	-	-	-
Services	265	219	44	25	14	3	-	2	-
Unclassified Est.	7	14	3	3	-	-	-	-	-
TOTAL	1,832	2,416	219	121	51	31	8	5	3

1-Excludes government employees, railroad employees, self-employed persons, etc.

Source: U.S. Bureau of the Census (1974).

The three-county area has a high percentage of families with income less than the government defined poverty level. Leon and Robertson Counties have more than twice the average state poverty percentage. Limestone County is higher or lower than the other counties in every category, thus bringing it closer to the state average. Still, it exceeds the State of Texas with more than 5 percent more families below the state poverty level (SwRI, 1975).

It is anticipated, however, that the per capita income for three-county area will continue to increase as projected in table E-15.

TABLE E-15. PER CAPITA INCOME PROJECTIONS IN 1967 DOLLARS

County	1960	1970	1980	1990	2000
Leon	1,016	2,198	3,011	4,342	6,394
Limestone	1,318	2,303	3,371	4,697	6,675
Robertson	1,186	1,898	2,704	4,031	6,107
State Average*	2,181	3,113	4,257	5,575	7,580

Source: Brazos River Authority (1974).

E-11. Hunting and Fishing. Access to lands for public fishing and hunting are virtually non-existent in the three-county area. SwRI (1975) reports:

> "Hunting and fishing are the most active sports of the area. Table E-16 consistently shows that most hunting is done in Leon and Robertson counties, even though they have smaller populations than Limestone County, with more hunting licenses sold and more deer killed in these two areas. The number of fishing licenses sold in Robertson and Limestone Counties is due to the fact that they have greater exposure to fishing waters. The available fishing waters for these two counties include Lake Springfield and Lake Mexia in Limestone County and the Brazos River in Robertson County."
>
> "There are no wildlife refuges, although Texas Parks and Wildlife has game wardens stationed throughout the area and the entire State of Texas, Deer and squirrel are the most prevalent game animals and are for the most part, found in Leon and Robertson counties as this area has an abundance of vegetation cover. Other animals, including coon, fox and coyote, are taken for their pelts or killed as nuisance pests. There are very

TABLE E-16. HUNTING AND FISHING IN THE THREE-COUNTY AREA

Item	Leon			Limestone			Robertson		
	1969	1970	1971	1969	1970	1971	1969	1970	1971
Resident Hunting Licenses	1,861	2,046	2,030	888	1,059	1,055	1,317	1,390	1,466
Resident Fishing Licenses	683	678	2,231	1,183	1,313	1,677	1,486	1,130	1,488

Source: SwRI (1975).

few turkey in the area and no kills have been reported for several years. Dove and quail are the only indigenous game birds; migratory game birds include duck and geese."

Hunting, for the most part, is conducted only on lands leased for hunting, or by landowners. Hunting leases in the area serve as supplemental sources of income for those landowners having lands with suitable wildlife habitat.

The inundation of 14,200 acres for Lake Limestone will reduce the acreage available for lease hunting. The lake, however, will significantly increase the water acreages available and accessible for public fishing.

E-12. Transportation Systems. A well-defined transportation network exists in the three-county area. Surface systems include railroads, highways, power transmission lines, and pipelines.

Railroads. Railroads serve 15 of the cities in the three-county area. However, Groesbeck and Mexia in Limestone County, and Hearne in Robertson County, are the only cities in this area to have regularly scheduled stops or service for local freight. There are a total of 234 rail miles inclusive in the three-county area with Leon having 75 miles of track, Limestone 40, and Robertson 119 (SwRI, 1975).

Highways. The total miles of highways, streets and roads in the three-county area are given in table E-17. Limestone County has the largest system with over 1200 miles of road. Leon County has the only interstate highway in the area; IH 45 connecting Dallas and Houston.

TABLE E-17. HIGHWAYS, STREETS AND ROADS

(Total Miles)

Category	Leon	Limestone	Robertson
	Rural		
Interstate	26.31	0.00	0.00
State Highway	101.34	110.70	80.69
Farm-Market	189.96	226.24	193.06
Total State System	317.61	336.94	27.75
County Roads and Streets	461.15	855.74	548.45
Grand Total	778.76	1192.68	822.20

TABLE E-17. (continued)

HIGHWAYS, STREETS AND ROADS

(Total Miles)

Category	Leon	Limestone	Robertson
	Urban		
Interstate	2.26	0.00	0.00
State Roads	14.80	16.89	6.38
Farm-Market	7.48	10.90	9.30
Total	24.54	27.79	15.68
City Streets	59.25	95.02	93.25
Grand Total	83.79	122.81	108.93

Source: SwRI (1975).

Power Transmission Lines and Pipelines. The total miles of power transmission lines and pipelines for the three-county area are given in table E-18. Leon County, which has the smallest road network, has the greatest number of miles of power transmission lines and pipelines.

TABLE E-18. POWER TRANSMISSION LINES AND PIPELINES

	County		
	Leon	Limestone	Robertson
Power Transmission Lines (Miles)	158	127	123
Pipelines (miles)	297	289	280

Source: SwRI (1975).

E-13. Airfields. Several private airfields are in the area; however, they are mostly unimproved fields with limited facilities. Of these, four are located in Leon County. There is a city airport located near Mexia, in Limestone County, whose facilities include a lighted runway. It is presently the only airfield in the county, and plans are now underway for construction of another. Bremond, in Robertson County, has a small field with limited facilities. Hearne has an airport with a lighted runway as well as one private airfield located to the south. Waco Municipal Airport is the closest commercial airstrip to the study area (SwRI, 1975).

An increase in highways, streets and roads, together with an increase in power transmission lines can be anticipated if development around the Limestone Lake project resembles those developments around similar projects.

F-1. Geology. Limestone Reservoir will be confined entirely to the Outcrop area of the Cenozoic Wilcox group. The origin of the Wilcox sediments is described by National Soil Services, Inc. (1973):

> The Cenozoic era marks a time of continuous struggle between the encroaching waters of the Gulf and large streams heavily laden with sediment. The sea endeavored to advance over the land, and the rivers constantly advanced the shoreline in the form of a deltaic plain. During the Wilcox stage, river-lain sands were extended seaward, and a continental facies of sediments containing land plants and fresh water fauna were superimposed over the marine strata.
>
> The sediments of the Wilcox group represent an epoch of heavy rainfall and abundant river flow. Rivers heavily laden with sand and silt meandered across the flat coastal plain. During flood stages, the rivers built natural levees of cross-bedded sands, and then overflowed the levees into the lowland between river courses to produce lakes and land-locked lagoons filled with fine silts, sandy clays, and clays. Later, shifting currents of these rivers undercut clay banks, rolled along chunks and balls of clay, buried them in sand banks and spread the sand over the lake beds. The humid climate produced a very thick growth of vegetation. Plant detritus was washed downward with silt and deposited with the clays. The heterogeneous mixtures of sands, clays, and lignites; the remarkable exposures of current bedding and stream ripple marks; and the lenticular shapes of sand and lignite layers can be explained only by a constant shifting of river beds over a flat and swampy coastal plain.
>
> The most characteristic lithologic features of the Wilcox terrestrial deposits are:
>
> Massive, cross-bedded sand
>
> Large broken chunks of petrified wood
>
> Lentils of black lignite
>
> Large rough-surfaced boulder-like concretions.

The Texas Bureau of Economic Geology divides the Wilcox group into three formations which include, in descending order:

(1) The Calvert Bluff formation, composed of mudstone, various

amounts of sandstone, lignite and ironstone concretions with glauconite occurring locally in the uppermost part. Lignite occurs mostly in the lower part of the formation in seams 1 to 20 feet thick. Average thickness 1200 feet. (2) The Simsboro formation, composed of mostly sand, some mudstone, clay and mudstone conglomerate. The sand is medium to coarse-grained, cross-bedded, and forms gently rolling hills covered by a dense growth of oak. Thickness is up to 300 feet. (3) The Hooper formation is mostly mudstone with various amounts of sandstone, minor lignite, ironstone concretions, and locally glauconite in the lowermost part. Average thickness is 500 feet.

F-2. Structure. The reservoir area is located in the broad region between the Mexia-Luling-Talco Fault system and the East Texas Embayment. This Fault system occurs along the outcrop of Early Eocene Midway Group rocks, generally in parallel arrangement with the north-northeast strike of these formations. The Mexia-Luling-Talco system is a complexly disturbed area of persistent linear faults, downthrown both to the northwest and southeast but preponderantly to the northwest. The Wilcox group overlies the Midway and dips approximately 50 to 75 feet per mile to the east southeast. Within a few miles down dip from the surface exposures, the dip increases to over 100 feet per mile and the thickness increases from 1200 feet near Donie in Freestone County to over 1500 feet in Leon County. Numerous salt domes occur along the western boundary of the East Texas Embayment. The Marquez dome located about three miles south southeast of the damsite has pierced the overlying formations bringing upper Cretaceous rocks to the surface. Fisher (1965) states that this dome has structural influence to a distance of five miles radially from the center and has caused numerous small, shear fault zones.

F-3. Esthetic Features. The landscape in the vicinity of the project is gently to steeply rolling with wooded areas, providing a generally attractive pastoral scene. Very few rock outcrops are apparent and no prominent scarps of other unique physical features occur. Erosion of soft surface materials which is active in ditches, hillsides and gullies, detracts somewhat from the general attractiveness of the landscape.

The presence of the lake would be considered a scenic enhancement by many observers. None of the formations bordering the proposed reservoir are resistant enough to provide a rocky shoreline but exposures of Simsboro sand in the upper reaches of the reservoir should provide sandy beaches.

Shoreline erosion by wind-driven waves, in addition to the erodibility of sandy and shaly clay materials in other areas, is expected to contribute to the general turbidity of the lake water.

F-4. Economic Geology. Mineral production in the three-county area for the years, 1970, 1971, and 1972 was as follows:

	Minerals produced in order of value	(1000)
1970		
Limestone Co.	Sand and gravel, clays, natural gas, petroleum, stone	$4689
Leon Co.	Natural gas, petroleum, natural gas liquids, stone	3149
Robertson Co.	Natural gas, stone, petroleum	49
1971		
Limestone Co.	Natural gas, sand and gravel, clays. petroleum	5092
Leon Co.	Petroleum, natural gas, natural gas liquids	3248
Robertson Co.	Natural gas, stone, petroleum	51
1972		
Limestone Co.	Sand and gravel, clays, natural gas, petroleum	4951
Leon Co.	Petroleum, natural gas	3053
Robertson Co.	Natural gas, petroleum, stone	54

F-5. Oil and Gas. The only mineral production in the immediate vicinity of the proposed reservoir is natural gas production at the Oletha gas field (see plate II-1). All active wells are above the maximum pool elevations for Lake Limestone.

All dry or abandoned oil or gas wells located within the proposed reservoir limits which could provide a pollution hazard will be plugged in accordance with the general conservation rules and regulations as administered by the Railroad Commission of Texas.

F-6. Minable Lignite Deposits. Lignite seams and thin laminations were encountered in all five borings drilled to investigate foundation conditions at the proposed damsite (National Soil Services, Inc., 1973). Approximately 40 borings were put down during subsequent drilling programs at the site and at least one lignite seam was encountered in almost every hole.

Eighteen exploratory holes were drilled on the R. E. Samuel property, approximately one to two miles north of the damsite.

Gamma ray, density, and resistance logs were run on 16 representative holes at the damsite and on the R. E. Samuel property to determine

how well the seams could be correlated between adjacent holes. In his analysis of these logs, Thomas B. Henderson, a consulting geologist, defines commercial lignite (minable lignite) as "beds of acceptable quality that meet the following depth and thickness requirements and have sufficient areal extent: minimum thickness, three feet, maximum depth, 150 feet; maximum stripping ratio, 15:1; minimum reserves. 10,000,000 tons." Henderson's conclusions are "Lignite beds ranging in thickness from one to nine feet were penetrated at depths shallow enough for open pit mining. The lack of continuity and consequent small reserves of these beds, however, preclude their being classified as commercial by today's standards."

An additional drilling program, performed by Texas Utilities Services, Inc., included 28 borings and encompassed the reservoir area. The thickest seam encountered outside of the R. E. Samuel property was 4.5 feet in hole No. 77-83. The total depts and lignite intercepts are shown below:

Hole No.	Total Depth	Lignite Intercepts (thickness-depth, feet)
45-22-S	150'	2½ - 28'
45-21-S	150'	0'
45-20-S	150'	0'
45-12-S	150'	2.5' - 92'
77-83	200'	3' - 150.5'; 4.5' - 162'
77-85	150'	3' - 76.5'; 2.5' - 127.5'; 3' - 152'
77-87	200'	2.5' - 94.5'; 3.5' - 141.5'; 3.5' - 152'
77-89	160'	2.5' - 49.5'; 2' - 91.5'; 1' - 120'; 3.5' - 137.5'; 2.5' 147'
45-175	150'	0'
45-165	150'	2' - 28'; 1' - 95'
45-7	150'	1' - 37'; 2' - 63'
45-8	150'	1' - 39'; 2' - 59'
45-18-S	150'	1' - 47'
244-5-L	200'	1' - 26';1' - 130'; 4' - 154'
244-6-L	200'	0'
244-4-L	150'	1' - 95'; 3' - 124'
244-3-L	200'	1' - 115'; 1' - 119'
244-2-L	200'	2' - 39'
77-161	200'	0'
77-3	150'	0'
77-4	150'	0'
77-1	150'	0'
77-2	150'	2' - 131'
77-11	150'	0'
77-12	150'	0'
71-2	185'	1.5' - 46.5'
71-8	145'	1' - 71'
71-24	400'	7' - 195'; 3' - 237'

F-7. Possible Lake Contamination by Fallout from Smoke Emissions. The upper end of Limestone Lake would be approximately 9 miles north-northeast and the Sterling C. Robertson Dam approximately 8 miles east of the Oak Knoll steam electric station, the closer of the two proposed power stations. The prevailing winds in this region are from the south. Because of dispersion and prevailing wind direction, it appears likely that very little of the particulate from smoke plumes would settle in the lake. Some fallout would be expected within the watershed of the lake and eventually would be carried into the lake by surface drainage.

G-1. Noise. The only data available on existing noise levels in the Limestone Lake area are those collected by SwRI (1975). Twelve test sites were chosen in the areas around the sites of Limestone Lake, the Oak Knoll electric generating plant and the Twin Oak electric generating plant. Ambient noise was recorded at each site at four different times during the day: 1) early morning; 2) mid-morning; 3) afternoon; and 4) evening.

Two types of noise data were measured at each site: 1) a histogram of dBA level versus number of readings; and 2) an octave band analysis. The former show the percentage of readings at each level over a 20-dBA range for a five minute time interval while the latter indicates the frequency bands which contribute the most to overall noise measured at each test site. Simultaneous measurements of relative humidity, barometric pressure, wind velocity and direction, and temperature were made.

Generally, the predominant area noise was found to range between low frequency background noise in the morning and afternoon, to high frequency insect noise in the late night and early morning. Detailed data concerning overall noise level and octave band analyses for each of the 12 sites are included in the study by SwRI (a975). Table G-1 summarizes the environmental noise levels found in the above study.

TABLE G-1

SUMMARY OF ENVIRONMENTAL NOISE LEVELS
("A" Weighted Scale)
Overall Noise Levels (dB)

Site	Early Morning	Mid-Morning	Afternoon	Evening
1	58	51	42	58
2	55	60	54	56
3	52	45	50	59
4	67	48	56	67
5	57	41	35	57
6	55	52	46	61
7	60	53	40	55
8	57	44	40	50
9	56	37	52	53
10	56	45	44	50
11	53	38	39	47
12	55	44	43	50

Data Source: SwRI (1975)

G-2. Noise Impacts. Estimates of noise impacts in area of Lake Limestone during construction and during the operational period by SwRI (1975) account for both the activities connected with the Sterling C. Robertson Dam and Lake Limestone project and the planned facilities of the Texas Utilities Services, inc. They estimate that during the construction period, average noise levels will range from about 78 to 85 dBA, depending on the particular phase of construction. They further estimate that, assuming the construction noise levels are measured at 300 feet from the sources, the noise levels will attenuate to background noise levels at distances of two to three miles from the construction sites. During the operational period for Lake Limestone, noise is expected to result primarily from activities related to recreation and will be made up primarily of power boat noises. Since population levels are extremely low in the area, no adverse community reaction to increased noise levels is anticipated.

G-3. Conclusions. The ambient noise levels in the vicinity of the project will rise both during the construction period and during the project operation. This will result in some degree of annoyance to future lakeside residents, but should pose no threat to health.

H-1. Air Quality. The only air quality data from the area of Limestone Lake are those collected by SwRI (1975). The measurement criteria were based on the National Primary and Secondary Ambient Air Quality Standards as well as guidelines issued by the Atomic Energy Commission for onsite meteorological programs for nuclear reactor stations and available instrumentation. Periodicity criteria were selected on the basis of National Primary and Secondary Ambient Air Quality Standards. Sampling procedures followed the recommendation of the U.S. Environmental Protection Agency. The sampling equipment used met the requirements of the U.S. Environmental Protection Agency and the Texas Air Control Board.

The objective of the SwRI air quality survey was to determine the existing average levels of particulates, sulfur dioxide, oxides of nitrogen, carbon monoxide, and ozone. Sixteen air quality samples were taken at periods of up to 24 hours between December 1973 and December 1974.

Carbon monoxide, ozone, sulfur dioxide, and oxides of nitrogen were found to be below the National Primary and Secondary Ambient Air Quality Standards and Texas State Standards (table H-1). Particulates from wind-blown dust on one occasion nearly exceeded the State standards for a one-hour period.

Table H-2 lists the air quality standards of the State of Texas and the United States.

H-2. Impact on Air Quality. During construction there will be an increase in particulate matter. Watering trucks will be used extensively in an effort to keep dust to a minimum during this period. Pollutants resulting from the internal combustion engines should be dispersed by the almost ever-present winds with no adverse environmental impacts. Disposal of waste materials and materials from clearing and grubbing operations must be done in an acceptable manner with regard to air quality considerations (see Appendix A-3, Vegetative Clearing).

H-3. Conclusions. No permanent adverse impacts on air quality are expected to occur as a result of the project.

TABLE H-1

SUMMARY OF AIR QUALITY MEASUREMENTS

Pollutant	Period of Measurement	Standards		Measurements			Units
		Primary	Secondary	High	Low	Avg.	
Particulates	1 hour	400	-	394.6	16.4	123.1	$\mu g/m^3$
	24 hours	260	150	79.	3.2	16.8	$\mu g/m^3$
Carbon Monoxide (CO)	1 hour	9.0	9.0	2.0	0	1.1	ppm
Ozone (O_3)	1 hour	0.08	0.08	0.084	0.003	0.044	ppm
Nitric Oxide (NO)	-	-	-	0.008	0	0.0004	ppm
Oxides of Nitrogen	-	-	-	0.090	0	0.004	ppm
Sulfur Dioxide (SO_2)	30 minutes	0.4	-	0.011	0	0.0024	ppm

Data Source: SwRI (1975)

TABLE H-2

FEDERAL AND TEXAS STATE
AMBIENT AIR QUALITY STANDARDS

Pollutant	Period of Measurement	Primary Standards		Secondary Standards	
		ppm	ug/m^3	ppm	ug/m^3
CO	1 hr	9	-	9	-
	8 hr	35	-	35	-
Ozone	1 hr	0.08	-	0.08	-
SO_2	30 min*	0.4	-	-	-
	3 hr	-	-	0.5	-
	24 hr	0.14	-	0.1	-
	Annual	0.03	-	0.02	-
Particulate	1 hr*	-	400	-	-
	3 hr*	-	200	-	-
	5 hr*	-	100	-	-
	24 hr	-	260	-	150
	Annual	-	75	-	60‡

Notes:
Quantities not otherwise noted not to be exceeded more than once per year.
* Texas special regulations. Single plant sources may not exceed these ambient levels in Texas at any point at anytime.
Annual arithmetic mean.
‡ Annual geometric mean

Data Source: SwRI (1975)

I-1. Existing Recreational Opportunities. Recreational opportunities and facilities in the Lake Limestone area are limited. The main attractions in the area are Lake Mexia and Fort Parker State Park.

Lake Mexia is a 1200 surface acre lake offering boating, swimming, water skiing and fishing. Fort Parker State Park contains 1.485 acres of wooded parkland with 750 acre Lake Springfield which is the main attraction.

Another attraction in the area is the Old Fort Parker State Historic Site. The fort was restored in 1967 and features authentic log blockhouses and stockade along with pioneer memorabilia.

The Lake Limestone area is popular for deer hunting. Other game found in the area are quail, dove, and squirrel. Although hunting is popular, it is limited by an absence of public land. Hunters either own the land, lease it from the owners for hunting, or receive permission from the landowner.

There are a few major recreation attractions outside the three-county area. Within a sixty mile radius of the damsite, Lakes Waco and Navarro Mills provide camping facilities along with picnicking, boating, and fishing facilities.

I-2. Future Recreation Without the Project. The reservoir site is primarily a wooded bottomland interspersed with cleared pasture areas. Some of the "improved" pasture areas will continue to gradually revert to native vegetation. Recreational use of the river will continue to be limited by the lack of public access and the periodic low- or no-flow conditions. Primary recreational use of the reservoir site will remain deer hunting.

If no public recreation lands are established at the reservoir site, it is safe to anticipate changes in the open spaces and woodlands that now exist by the year 2020. Encroachment on bottomlands can be anticipated with a substantial loss in wooded cover as the land is converted for grazing. Currently the land is overgrazed. If overgrazing continues, more growth of undesirable plant species can be anticipated.

Public recreational opportunities in the three-county area will remain much as they are: Fort Parker and Old Fort Parker State Parks. Private outdoor recreation activities will continue to be primarily comprised of hunting and fishing on private lands. There will continue to be a lack of water-related recreational opportunities for the public in the three-county area.

I-3. Impact on Recreation. Lake Limestone is expected to provide an aesthetically pleasing lake with associated recreation for the people in

Leon, Limestone, and Robertson Counties, and additional surrounding counties. It will fill a void caused by a lack of sufficient water-based recreation in the area while also providing a boost to the area's economy in the creation of lake-related investments. The lake is expected to receive heavy visitation from fishermen during the earlier years of its existence when it offers excellent fishing during its "hot", new-lake stage. Other attributes of the lake which will contribute to high visitation are the large size of the lake (14,200 acres and 130 miles of shoreline) and the high water quality which the lake is expected to maintain. Additionally, the construction of Lake Limestone will create a river fishery below the dam. The Navasota River is not heavily fished but the construction of Sterling C. Robertson Dam and the subsequent low-flow water releases will enhance a river fishery which is more productive than presently exists. The characteristics of the outflowing water will differ from the river water. Outflowing water will be less turbid and have lower levels of many nutrients. The constant flow during low-flow water releases will enable the establishment of fishes and other organisms which cannot survive the regular summer high temperatures and intermittent stream flows of the upper Navasota River.

Present plans call for the acquisition of five access areas with the total acreage to be less than 150 acres. Initial site development includes necessary sanitation facilities, boat ramps, and parking areas. It is expected that these areas will be further developed at some later date by the construction of picnic areas, and camping facilities. This would necessitate equipment and manpower to deal with the associated problems of solid waste disposal, law enforcement, etc.

I-4. Conclusions. The project will provide water-oriented recreational opportunities for a large number of people--many more than now use the area for hunting and fishing. The good quality of water anticipated will provide an aesthetically pleasing lake for many years to come.

TABLE T-1
METRIC-ENGLISH CONVERSION TABLE

Length

1 centimeter (cm.) = 0.3937 inch
1 foot (ft.) = 0.3048 meter
1 inch (in.) = 2.54 centimeters
1 kilometer (km.) = 0.621 mile
1 meter (m.) = 39.37 inches 1.094 yards
1 millimeter (mm.) = 0.03937 inch

Areas or surfaces

1 acre = 43,560 square feet = 4,840 square yards
1 square centimeter (cm^2) = 0.155 square inch
1 square foot (sq.ft.) = 929.030 square centimeters
1 square inch (sq in,) = 6.452 square centimeters
1 square meter (m^2) = 1.196 square yards
10.764 square feet
1 square yard (sq.yd.) = 0.836 square meter

Capacities or volumes

1 cubic centimeter (cm^3) = 0.061 cubic inch
1 cubic foot (c.ft.) = 7.481 gallons
0.0283 cubic meter
1 cubic inch (c.in.) = 16.387 cubic centimeters
1 cubic meter (m^3) = 1.308 cubic yards
1 cubic yard (cu.yd.) = 0.765 cubic meter
1 gallon (gal.) (U.S.) = 231 cubic inches
3.785 liters
1 liter (l.) - 1.057 liquid quarts
0.908 dry quart
61.025 cubic inches
1 milliliter (ml.) = 0.061 cubic inch
1 quart (qt.) (dry) = 67.201 cubic inches
1.101 liters
1 quart (qt.) (liquid) = 57.75 cubic inches
0.946 liter
1 acre-foot (ac.ft.) - 1.2335 hectare-decimeter

Weights or masses

1 gram (g.) = 0.035 ounce Avoirdupois
1 kilogram (kg.) = 1,000 grams = 2.205 pounds

1 microgram (mg.) = 0.000001 (one millionth) gram
1 millogram (mg.) = 0.001 (one thousandth) gram
1 ounce Avoirdupois (oz. Avdp.) = 28.350 grams
0.911 troy or apothecaries ounce
1 ounce, troy or apothecaries (oz. t. or oz. ap.) = 31.103 grams
1.097 avoirdupois ounces
1 pound Avoirdupois (lb. avdp.) = 453.59237 grams
1.215 troy or apothecaries pounds
1 ton, gross or long ton (gross tn.) = 2,240 pounds
1.12 net tons
1.016 metric tons

1 ton, etric (t.) = 2,204.623 pounds
0.984 gross tons
1.102 net tons
1,000 kilograms
1 ton, net or short (tn.) = 2,000 lbs.
0.893 gross ton
0.907 metric ton

Flow rates table

1 mgd = 1.55 cfs = 11.59 gallons per second
1 cfs = 448.8 gallons per minute
1 acre foot/year = 892.7 gpd - .62 gallons per minute


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